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FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Asheville, N. C.	June 22-26, 1931	Summer Convention	(Closed)
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	May 25, 1931
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so tha their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for al meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION, Hot Springs, Va., (A. W. Berresford, 420 Lexington Avenue, New York) May 18-23, 1931.

NATIONAL ELECTRIC LIGHT ASSOCIATION, Middle West and Nebraska Divisions, Excelsior Springs, Mo., (Thorne Browne, 1527 Sharp Bldg., Lincoln, Neb.) May 20-22, 1931.

NATIONAL ELECTRIC LIGHT ASSOCIATION, Annual Convention, Atlantic City, (A. J. Marshall, 420 Lexington Ave., New York) June 8-12, 1931.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS, Cleveland, Ohio, (J. F. Kelly, Empire Bldg., Pittsburgh, Pa.) June 15-19, 1931,

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, Summer Convention, Pasadena, Calif., (Chas. F. Roos, Secy., Smithsonian Institute, Washington, D. C.) June 15-20, 1931.

NORTHWEST ELECTRIC LIGHT AND POWER ASSOCIATION, Annual Convention, Boise, Idaho, (Berkeley Snow 1206 Spalding Building, Portland, Ore.) June 17-20, 1931.

AMERICAN SOCIETY FOR TESTING MATERIALS Annual Meeting, The Stevens Hotel, Chicago, (C. L. Warwick Secy., 1315 Spruce St., Philadelphia, Pa.) June 22-26, 1931.

PACIFIC COAST ELECTRICAL ASSOCIATION, Annua Convention, Del Monte, Calif., (K. I. Dazey, 447 Sutter Street San Francisco, Calif.) June 24-27, 1931.

ROCKY MOUNTAIN DIVISION N. E. L. A., Annual Convention, Stanley Hotel, Estes Park, Colo., Sept. 2-4, 1931.

ILLUMINATING ENGINEERING SOCIETY, Annual Convention, Pittsburgh, Pa., October 13-16, 1931.

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This Month—

Front Cover—"Arizona"

110-kv. line of the Salt River Valley (Arizona) Water User's Association which ties the 33,000-kva. Horse Mesa hydro plant into a transmission loop which includes the power house at the famous Roosevelt Dam. David F. Wilkie (A'22), superintendent of power plants is standing by the tower.

—Electrical West Photo

Stroboscopic Moving Pictures 327
H. E. EDGERTON

D-C. Power for Industrial Plants 329
R. D. ABBISS & D. C. WEST

Some Factors Affecting Stability 332
W. A. MERRIAM & H. R. ARNOLD

A High-Speed Submarine Cable 337
J. W. MILNOR & G. A. RANDALL

Noise—A Factor in Machine Design and Operation:

Difficulties in Measuring Machine Noise . . . 340
B. F. BAILEY

A New Meter for Noise Analysis 342
T. G. CASTNER, E. DIETZE, G. T. STANTON & R. S. TUCKER

Magnetic Noise in Synchronous Machines . . 344
Q. GRAHAM, S. BECKWITH & F. H. MILLIKEN

Elastic Supports for Rotating Machinery . . 347
E. H. HULL & W. C. STEWART

— Turn to Next Page —

Measurement of Machinery Noise 349
H. B. Marvin

Mitigation of Substation Noise 351
E. A. Bishop

Noise from Induction Regulators 352
J. P. Foltz & W. F. Shirk

Impulse Tests Made on Substations 354
R. N. Southgate, A. S. Brookes, E. R. Whitehead & W. G. Roman

Automatic Arc Welding 358
G. H. Koch

Percentage Differential Transformer Protection . 361
R. E. Cordray

Automatic Speed Regulation 363
J. H. Ashbaugh

Interchange of Industrial Power for Better Operating Efficiency 365
W. B. Skinkle

Short Items—

Determining the Flexibility of Mica Sheets . 336
Metal-Clad Synchronous Motors for Nitrate Plants 339
Artificial Sunshine for the Modern Office . . 357

News of Institute and Related Activities ◆ ◆ ◆ ◆ 368
Local Institute Meetings 380
Employment Notes 387
Membership 389
Engineering Literature 390
Industrial Notes 396
Officers and Committees
(For complete list see pages 81-84 of the January 1931 issue)

OF PARTICULAR interest in this month's news are the complete program outline for the annual Summer convention to be held in Asheville, N. C. in June (*pp. 368-371*); a review of the discussion which transpired at the recent district meeting in Pittsburgh (*pp. 372-3*); notice of an economic conference to be held in August at the engineering camp of Stevens Institute of Technology (*p. 373*), and a report upon living conditions in Russia. (*pp. 374-5.*)

B. F. BAILEY, besides having been professor of electrical engineering at the University of Michigan for the past eighteen years, has been a director and consulting engineer for several electrical manufacturers; also an expert patent case witness. He is the author of many books and articles on technical subjects; in this issue he describes some of the noise abatement work carried on at the University under his direction and introduces a symposium on the importance of noise reduction in electrical machinery. (*See p. 340.*)

THE NOISE PROBLEM is broadly treated in six other articles by four engineers of the Bell Telephone System, five of the Westinghouse Company, three of the General Electric Company, and one of the Commonwealth Edison Company, Chicago; each contributes the results of experience gained in his own particular field. (*See pp. 342-352.*)

J. W. MILNOR, for the past twelve years research engineer for Western Union Telegraph Company, and one of the foremost telegraph engineers in the entire world, gives some of the features of design and operation in connection with the New York-Azores high-speed submarine telegraph cable installed in 1928 and ever since then in successful duplex operation. G. A. Randall of the same company assisted Mr. Milnor in preparing this article. (*See p. 337.*)

INDUSTRIAL-UTILITY interconnection problems, one of the subjects to which an entire session was devoted at the recent district meeting at Pittsburgh, are discussed, and advantages accruing to both systems from a free interchange of power interestingly pointed out, by W. B. Skinkle of the Subsidiary Companies, U. S. Steel Corporation. (*See p. 365.*)

Stroboscopic Moving Pictures

By means of moving pictures taken stroboscopically it is possible to see the rotor of a synchronous machine just as though one were actually revolving at synchronous speed with the rotating field of the stator windings. Newly developed thyratron tubes provide sufficient light for taking the pictures.

By H. E. Edgerton

Associate A. I. E. E.

Massachusetts Institute of Technology
Cambridge

OF THE SEVERAL different methods of determining the very important, but rarely measured angular displacement of a synchronous machine, stroboscopic observation is the most direct and straightforward. This method requires a minimum of apparatus; namely, a disk rigidly attached to the shaft of the synchronous machine, a suitable stationary scale for recording the displacement, and an intermittent light source operating in time phase with the terminal voltage of the machine. The disadvantage of the stroboscopic method in the past has been that the measurements had to be recorded visually, and thus the accurate measurement of transient variations of angle has been practically impossible because of the inability of an observer to record the phenomena during the short duration of most transients.

With the stroboscopic device described in this article, enough light is produced so that a motion-picture record can be made of the angular displacement of a synchronous machine. A mercury vapor arc is used which produces the characteristic blue light well known for its powerful actinic properties. The tube used to produce the arc is a thryatron containing grids that control the electrical transients which are the source of the stroboscopic light.

Stroboscopic moving picture records will provide important observations for those who are concerned with the operation of synchronous machines. These moving pictures will be especially valuable when correlated with oscillograms taken simultaneously. The "strobograms," as these pictures may be called, will furnish power engineers with information regarding the angular displacements of their generators, condensers, and lines during switching and short-circuit disturbances. They will tell the users and designers of synchronous motors exactly how far the rotors swing, their period of motion, and the damping of their oscillations for violent, sudden load changes such as are common in the steel industry. Photographic records will be valuable also in studying the steady-state time-angle variations.

In addition this method of photographing stroboscopically illuminated objects will provide research workers with the means whereby many experimental investigations may be made. It is especially adapted for studying the motion of mechanical objects such as springs, cams, valves, and other devices.

Among the important requirements for a stroboscope suitable for photographic purposes, are:

1. Short duration of the light. If the illumination extends over an appreciable period of time the image will be blurred. A rough calculation shows that the duration of the main flash should not be longer than about 10 microseconds.

2. Rich actinic light. Photographic film is much more sensitive to ultra-violet and blue light than to red. For this reason a mercury discharge tube is used in place of the commonly used neon tube. The light from a mercury arc is composed of strong blue and ultra-violet colors. Some of the ultra-violet radiations are, however, absorbed by the glass walls of the tube.

3. Reliability of light-flash control. A synchronously rotating object viewed by a stroboscope will not be stationary if there is any variation in the interval of time between discharges in the stroboscope circuit. This time interval can be controlled very accurately by applying sufficient voltage to the thyratron grid.

THYRATRON CIRCUIT

An arrangement of apparatus capable of producing a powerful stroboscopic light is shown in Fig. 1. Current waves for various branches of the circuit are included also in this illustration. Light is obtained from a condenser discharge through the thyratron tube; and since the only impedance in the circuit besides the thyratron is that of the leads connecting the tube to the condenser this discharge is very rapid, lasting only about 10 microseconds or even less. An intense momentary light flash is thus obtained.

The sequence of events through a cycle of operation will be described in detail. When the grid is negative no current is flowing from the main anode because the grid has the property of extinguishing the arc. Such grid action is contrary to the usually explained rules of thyratron operation but occurs here because of the low density of the anode current and the large condenser in parallel with the arc. During this half cycle, current flows from the 500-volt d-c. source through the resistance into the condenser in the well-known exponential relationship. The resistance and capacity are adjusted so that the potential across the condenser becomes practically 500 volts during the half cycle that the grid is negative. Replacing the resistance *R* with inductance *L*, or using both in series with the condenser, will give a still higher voltage across the condenser, if *R*, *L*, and *C* have proper values.

At the end of the charging half cycle, the grid becomes sufficiently positive to allow current to flow from the anode. The charge that has been accumulated in the condenser will then be discharged through the tube. If short, heavy-stranded leads are used to connect the condenser to the tube the holding arc may be extinguished at this time by the condenser discharge, but this difficulty may be overcome by introducing a choke coil into the holding circuit and a small resistance in series with the condenser. From a recent study by Krug, (of the arc striking speed of a mercury arc rectifier), (*Arch. f. Techn. Physik 11*, 1930, 6 p. 227, and *E. u. M.* 48, June 8, 1930, p. 567), it is known that only 0.01 to 0.1 microsecond is required to start the arc. Thus the thyratron acts virtually as a short circuit across the condenser.

For the remainder of the half cycle following the condenser discharge the grid is positive and the main anode carries a current which is limited in value by the resistance *R*. The light from this current is not intense and is negligible in comparison with the condenser flash. With the pool-type of thyratron this current is oscillatory under some conditions, giving faint ghosts trailing behind the main discharge. A negative bias and a peaked a-c. voltage on the grid eliminates these oscillations.

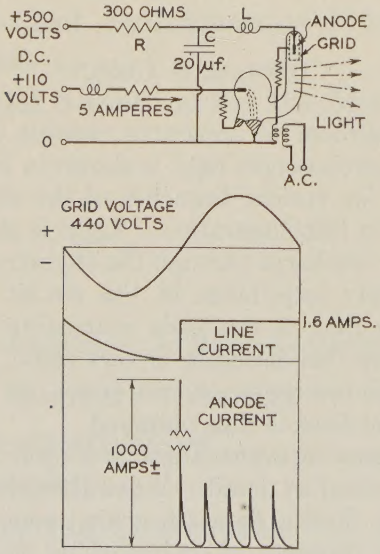

Fig. 1. Schematic diagram of thyratron circuit; voltage and current relations in various parts of the circuit are shown below

At the completion of the operating cycle the grid again becomes negative thereby extinguishing the anode current. The condenser then begins to accumulate a charge for the next flash.

STROBOGRAMS TAKEN

With the thyratron and other apparatus just described, a 160-hp. synchronous motor was photographed stroboscopically as it pulled into step. The tube was hung on a framework so that its light would fall directly upon the field structure. White cardboard collars were tied around the poles and alternately marked *"N"* and *"S."* The amortisseur rings were painted white and the protruding bars black. A general view of the arrangement in operation is shown in Fig. 2.

Strobograms taken during the transfer from operation on half voltage, which was used for starting the motor, to full voltage, are shown in Fig. 3. These consist of a sequence of enlarged, 16-mm. moving picture frames and were taken on panchromatic film at 16 frames per sec. with a lens opening of f-1.9.

The particular thyratron used for these tests had two anodes, each was connected to a circuit such as shown in Fig. 1 but the grids were supplied from a common transformer. No apparent difference in the time of discharge was experienced, except when the tube was cold.

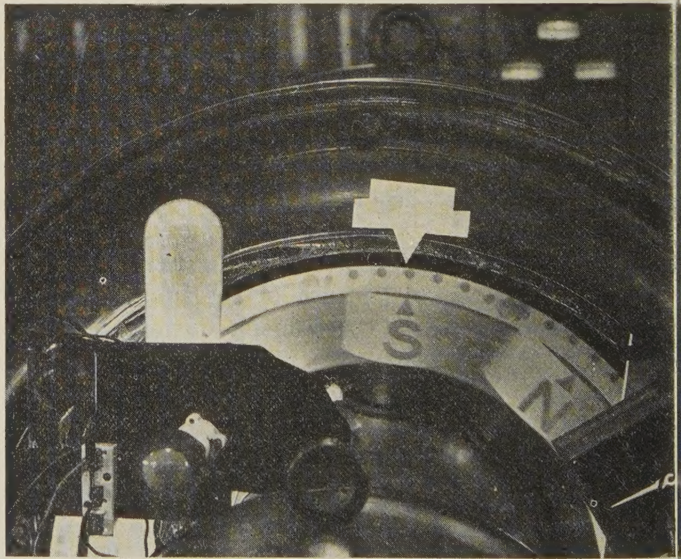

Fig. 2. Thyratron arranged for taking stroboscopic movies of a 160-hp. synchronous motor

A special camera which would record the rotor displacement angle for each cycle could easily be made. This camera would require no shutter and no mechanical framing movement. The film could be run through the camera at a constant speed and just fast enough so that the exposures would be spaced correctly.

A simultaneous reading of time could also be taken with the angle on the strobograms by photographing a clock hand driven by a telechron clock motor running at one revolution per second. This would be quite necessary for accurate testing since there is no definite relation between the frequency of the camera shutter and that of the intermittent light.

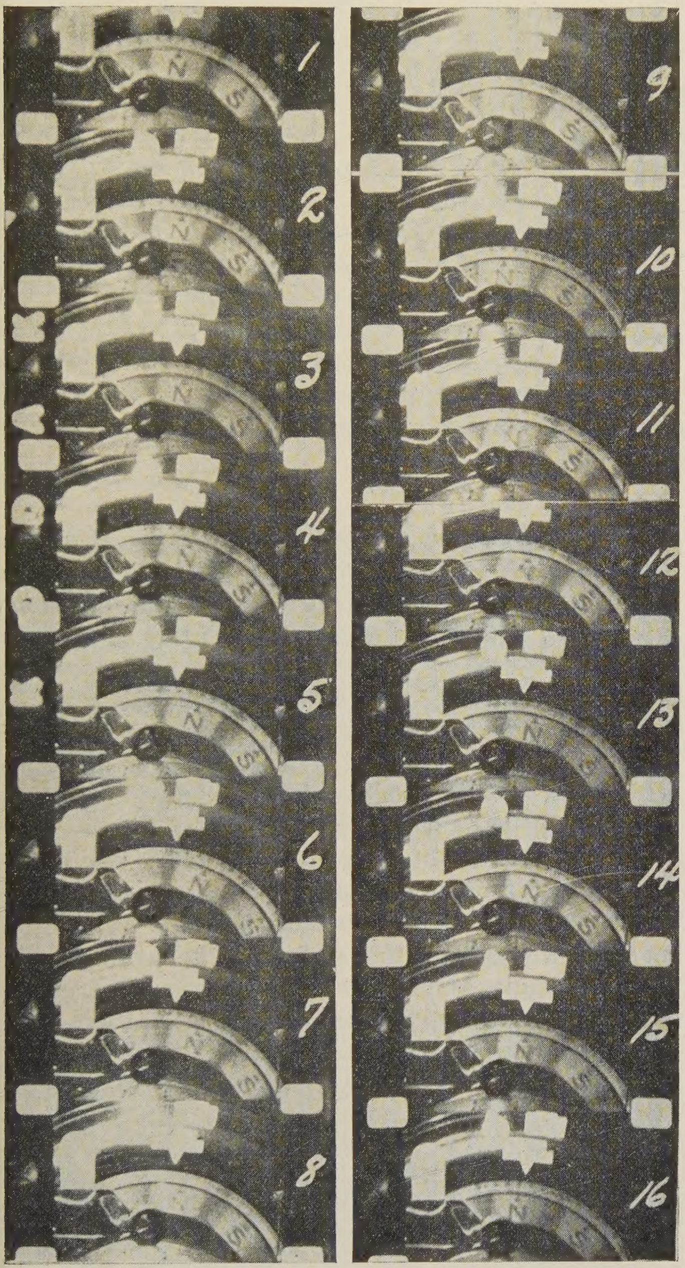

Fig. 3. "Strobograms" of a synchronous motor as it was switched from half to full voltage. Increased angular displacement may be noted as the supply switch was momentarily open during changeover (4-7)

D-C. Power for Industrial Plants

Many large industrial plants depending upon d-c. power for machinery and process operation can ill afford to continue to overlook the economies of modern a-c.—d-c. conversion apparatus and decentralized d-c. supply.

By R. D. Abbiss
Non-Member
Carnegie Steel Company
Pittsburgh, Pa.

D. C. West
Member A. I. E. E.
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Pittsburgh, Pa.

IN THESE DAYS of 200,000-kva. turbine-generators, 90,000-kva. transformer banks, 220-kv. transmission lines, and the many other spectacular achievements in the electric power field, it is only natural that there has been acquired the habit of picturing the electrical industry almost entirely in terms of alternating current. It is a common failing to overlook the fact that hundreds of thousands of less spectacular devices go quietly and unobtrusively about the business of consuming at least one-quarter and probably one-third of the total production of electric energy in the form of direct current. Dominance of the polyphase a-c. system rests on the very solid foundation of fundamental economy and flexibility in generation, transmission, and distribution, together with the sturdy simplicity of the induction motor. However, direct current retains a prominent and apparently permanent place in the field of utilization because of its necessity in electrolytic work and because the flexibility of speed control inherent in the d-c. motor is of such great value in many applications. To realize these advantages of both a-c. generation and d-c. utilization it is necessary to pay the price of providing and operating a system of power conversion and low-voltage d-c. distribution. Thus an intermediate system, an additional overhead, is imposed by these differing methods of production and consumption of electrical energy.

Now in this, as in any case, the ultimate problem of the engineer is to reduce the over-all cost to a minimum consistent with adequate and reliable service. In many systems there is need for service improvement as well as cost reduction. Experience has shown that in the field of power conversion and d-c. distribution, both results can be realized by essentially the same means and methods. Much time and effort expended over a

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From "Conversion and Distribution of General-Purpose D-C. Power in Large Industrial Plants," presented at the A. I. & S. E. E. session held jointly with the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 13, 1931.

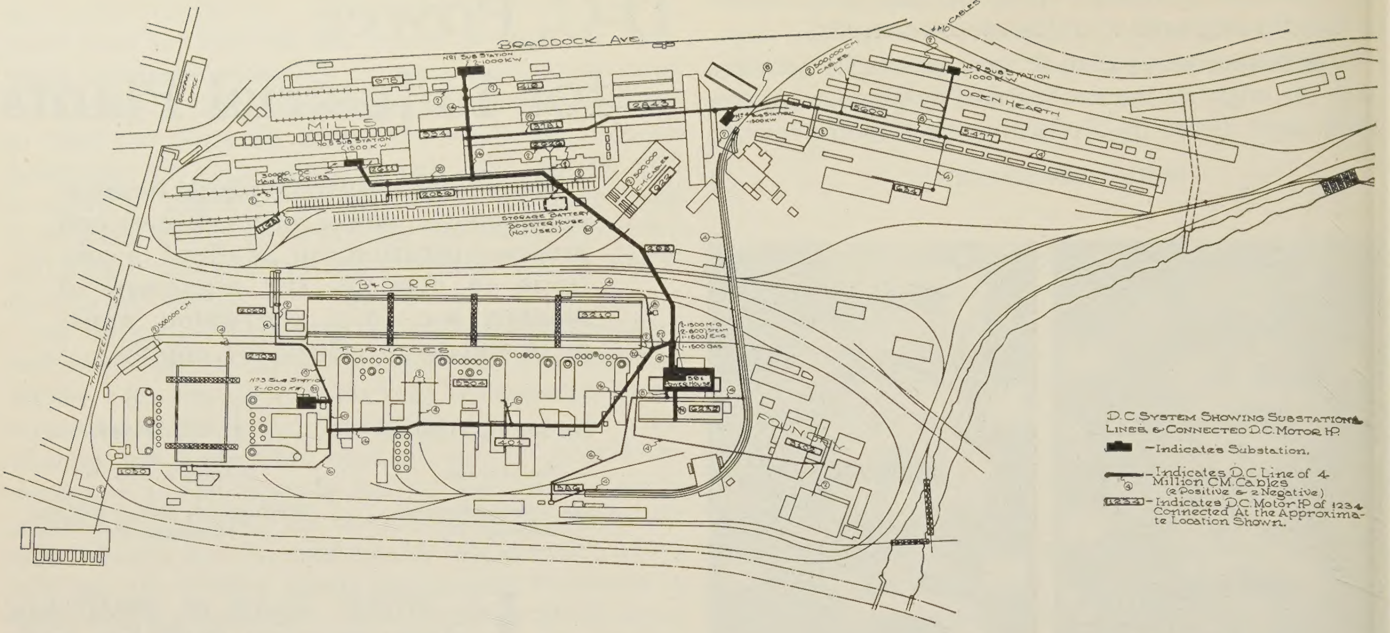
BRADDOCK AVE.
MILLS
OPEN HEARTH
B & O R R
FURNACES
STORAGE BATTERY BOOSTER HOUSE (NOT USED)
D.C SYSTEM SHOWING SUBSTATIONS LINES, & CONNECTED D.C. MOTOR HP.
-Indicates Substation.
-Indicates D.C Line of 4-Million CM.Cables (2 Positive & 2 Negative)
1234 -Indicates D.C. Motor HP of 1234 Connected At the Approximate Location Shown.

Fig. 1. Plan of Edgar Thomson works of the Carnegie Steel Company, Pittsburgh, showing d-c. power system

period of years has brought the apparatus for such a system to a high state of development; however, it probably has not been fully appreciated that the economy and improved operation which this modern equipment make possible can be realized fully only through careful planning and proper coordination of the whole system. It is the purpose of this article to bring to the attention of the industry the benefits to be derived through modernization, to state the problem and outline the procedure of system study, to point out the major engineering and economic considerations involved, and to illustrate by describing the evolution and present arrangement of a typical large system.

In the early days of the electrification of industry d-c. power was supplied to a large extent by low-speed engine-driven d-c. generators. Even today many of these elephantine machines are in regular operation, consuming a large amount of energy in the form of losses, requiring a large force of men for operation and maintenance, and taking up an excessive amount of more or less valuable space. In such cases marked economy usually can be effected by changing over to a-c. power supply and modern, high-speed efficient conversion equipment. In certain cases where process steam otherwise would be wasted, high-speed turbine-driven d-c. generators can be used to advantage.

The development of reliable and efficient conversion equipment was an important step forward, but for many years constant operating attendance was necessary at each substation because only manually-operated switching equipment was available. As a result of many large industrial plants having grown up under the limitations imposed by engine-driven d-c. generating equipment and manually-operated conversion equipment, it is not uncommon to find the total d-c. capacity concentrated into one or two large stations, although a large part of the d-c. power must be used at remote parts of the plant. Such an arrangement probably represented good economic practise at the time it was installed; however, a study will show usually that growth of the plant and the development of new apparatus have effected a marked change, and that the present-day result is a rather costly compromise between high distribution loss, low voltage at the load, and an excessive amount of distribution copper.

With the advent of completely automatic and unattended operation of conversion units it became economically feasible to distribute the d-c. substation capacity throughout the system. The average d-c. feeding distance thus is greatly reduced with a corresponding decrease in distribution cost. The saving can be taken in the form of less copper, reduced losses, or both. If improvement in voltage at the load is necessary the advantage gained can readily be turned to that purpose. It is of course necessary in any case to transmit approximately the same amount of power over about the same distance from the a-c. source to the distributed d-c. load. The fundamental economy lies in the fact that, with distributed conversion equipment, the bulk distribution of this power is over a relatively high-voltage three-phase circuit, say 6.6-kv., instead of over a 250-volt d-c. circuit.

There are other advantages to be derived from the use of automatic equipment which, although more or less intangible and difficult of exact evaluation, are important and valuable. Automatic switching equipment provides a nicety of sequence and a fundamental correctness of all switching and control operations which cannot be expected under manual control. Experience in a wide variety of applications has demonstrated that this results in a higher standard of service reliability, freedom from long and expensive outage, and greater flexibility of system operation.

The Edgar Thomson works of the Carnegie Steel Company provides a typical example of a completely automatized system of d-c. power supply which has evolved gradually from the early days of centralized engine-driven equipment. The original installation comprised three engine-driven d-c. generators totaling 1,600 kw. and feeding out radially over a comparatively restricted area. As the d-c. load increased with plant growth more units and more distribution copper were added until the total engine-driven d-c. capacity at the power house was increased to 6,900 kw. including a 1,500-kw. gas-engine unit. With further expansion the load demand became so heavy that some decentralization of d-c. power supply was almost a necessity. Subsequent additions have been in the form of conversion units located at various points throughout the plant as shown in Fig. 1. The first three substations at first were manually operated because automatic switching equipment was not available at that time. They were automatized subsequently to secure improved operation and still better economy.

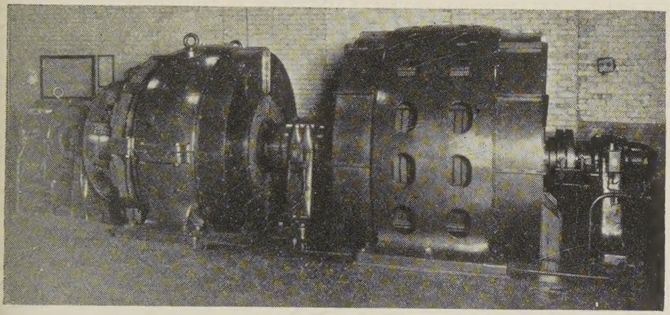

Fig. 2. A new 1,500-kw. automatic motor-generator set in the Edgar Thomson works

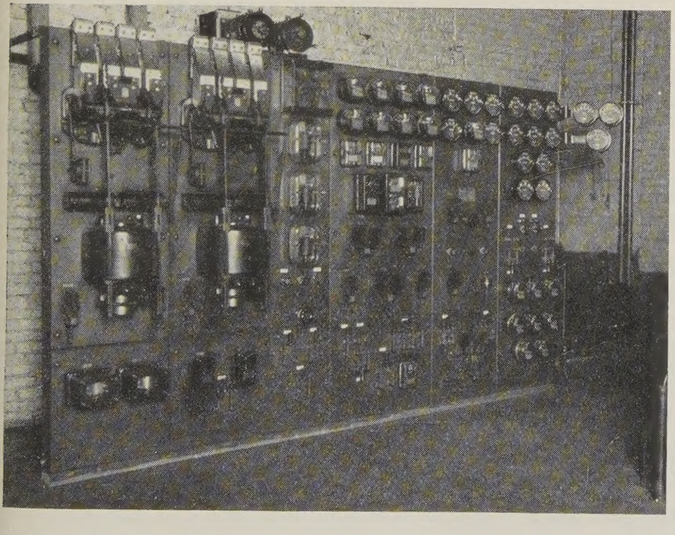

Fig. 3. D-C control panel for motor-generator set of Fig. 2

The present arrangement was completed with the installation of three new 1,500-kw. automatic motor-generator units similar to that shown in Fig. 2. One each of these units was placed at substations Nos. 4 and 5 and the power house. At the same time a similar manually-operated conversion unit in the power house was automatized. This permitted the retirement of all engine-driven d-c. equipment from active service, although the gas-engine unit and three steam-driven units were retained in place as standby capacity. The result is a complete automatic system of d-c. power supply consisting of 11,000 kw. of distributed automatic conversion equipment, all interconnected through the main distribution system.

The transfer of load from the centralized engine-driven units at the power house to conversion units near the load centers has greatly reduced the average d-c. feeding distance. The predicted saving in distribution losses has been realized in service. Furthermore, primary power now is generated in a relatively large and efficient turbine unit instead of in the small-capacity low-speed reciprocating units. Fig. 4 presents a contrast which illustrates the progress which has been made in the utilization of space and materials. One of the two 1,500-kw. motor-generator sets may be seen between the gas engine unit of the same rating and the

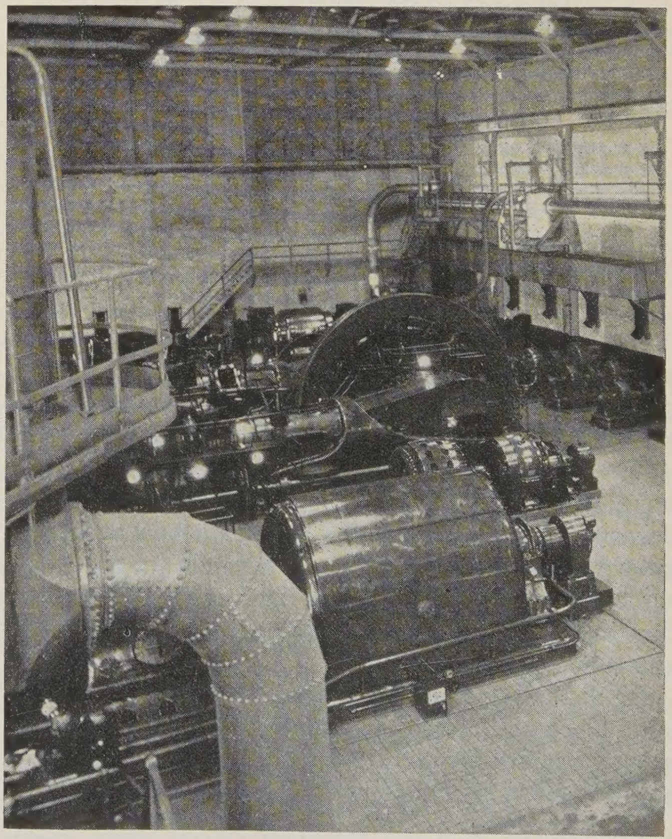

Fig. 4. A contrast in efficiency of space utilization between the old and the new

new 15,000-kva. turbine-generator. The picture was taken from the upper deck of the 1,500-kw. vertical cross-compound steam engine, giving some conception of its physical size.

It should be pointed out that the arrangement of this system necessarily differs to a certain extent from that which might be proposed for a similar, but entirely new installation. For that reason it probably is of greater value as a practical example because the problem ordinarily will arise in connection with the extension or rehabilitation of an existing plant. In any case it is important to realize that joint consideration of load and production requirements, d-c. distribution, substations, and a-c. power supply, is essential to a proper analysis and economical solution. It is only by such a study of the whole system of an industrial establishment that the major component parts can correctly be coordinated and proportioned.

Some Factors Affecting Stability

With the tremendous growth of power-transmission systems has come a corresponding increase in the seriousness of the stability problem. Regulation of generator excitation so that it will follow rapid changes in load constitutes a major part in the solution of this involved problem. Data show that the characteristics of all synchronous apparatus connected to a system must be considered.

By W. A. Merriam and H. R. Arnold**

Senior Students in Electrical Engineering (1929)
University of Colorado, Boulder

POWER limits of transmission systems present a problem which during the last few years has assumed a most important place in the electrical engineering field. When generators became larger, lines longer, and synchronous motors came into general use, it became apparent that some factor other than the temperature rise was beginning to limit the amount of power which could be handled. This factor has become known as the stability limit, and depends not only upon the design of the transmission line itself but also upon the characteristics of its associated synchronous generators and motors.

In the generation, transmission, and utilization of large blocks of power, the stability limit of a system is usually reached before the temperature of the apparatus has reached its maximum safe operating value.

As an example, reference is made to a report on the stability limits of the 220-kv., long distance transmission system of the Southern California Edison Company. This report disclosed that:

1. Adding a new plant and a second unit to the generating capacity at Big Creek would result in a hazard to the continuity of service because the stability limit of the system would then fall below the rated capacity of the combined power plants.

2. When the total system load became approximately 400,000 kw. or more, the condenser capacity then installed would not be sufficient to permit the 375,000 kw. rated output of Big Creek to be transmitted, without calling on the steam plants for wattless energy.

3. While the rated capacity of the Big Creek plant was 375,000 kw., its maximum stability limit with one line in operation was only 294,000 kw. and with two lines in operation, 370,000 kw.

4. The stability limit of that system could be improved by increasing the transmission lines up to a certain number. Should that number of lines be exceeded, however, the system stability would again be lowered.

CHARACTERISTICS OF SYNCHRONOUS MACHINES

In general the characteristics of synchronous machines are fairly well understood and do not need to be treated here in any great detail. However, for the purpose of bringing out those characteristics which bear directly upon the question of stability, a few of the important features will be outlined.

For a synchronous generator it may be said that:

1. The phase angle by which the terminal voltage lags the generated voltage varies with the magnitude and power factor of the load and also with the synchronous reactance of the machine.

2. That part of synchronous reactance which is due to armature reaction varies also with the magnitude and power factor of the load current; and with respect to the main field, may be either cross-magnetizing, bucking, or boosting, depending upon whether the load current is in phase, lagging, or leading with respect to the generated voltage.

3. In order to maintain a constant terminal voltage, the field current must be increased with lagging power-factor loads, and decreased with leading power-factor loads.

4. Decreasing the field current causes the generator to operate on the lower, unstable part of its magnetization curve, thereby decreasing the power limit above which it will drop out of synchronism.

From the foregoing statements it is obvious that any load on a generator which tends to raise the power factor or cause a leading current to be drawn decreases the stability limit of the machine since it reduces the load at which a synchronous motor connected to the generator in question will fall out of step with it. It also very materially decreases the synchronizing power and

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From "Some Factors Affecting the Power Limits of a Transmission System," National Prize Branch Paper, presented at a joint meeting of the Denver Section and the University of Colorado Branch, A. I. E. E., April 26, 1929.

*Now Assoc. A. I. E. E.

tends to cause the generator to fall out of step with other generators during line disturbances. If the field excitation of the generator could be quickly raised above normal during the time of a disturbance, the machine would be more stable and the liability of its losing synchronism would be greatly reduced.

A similar tabulation outlining those features of synchronous motors which bear directly upon stability limits is as follows:

1. Power factor depends upon both the field excitation and the load on the motor.
2. If the excitation is decreased below normal, the induced voltage or counter e. m. f. is less than the applied voltage, and the motor will draw a lagging current.
3. If the excitation is increased above normal, the induced voltage is greater than the applied voltage and the motor will draw a leading current.
4. Increase in load increases the angle between the applied voltage and the induced voltage. When these two are equal, the phase displacement at which breakdown occurs is 60 deg.
5. The breakdown or pull-out-angle, however, can be increased above 60 deg. by increasing the motor field current. Therefore, an overexcited synchronous motor is more stable than an underexcited one.
6. If the field current is kept constant, the maximum torque that the motor can exert will vary directly with the applied voltage.
7. If the field current is varied with the applied voltage, then the maximum torque that the motor can exert will vary as the square of the applied voltage.
8. Increasing the field current for any given load decreases the angular displacement between the induced and applied voltages. Also, with small field currents, this displacement increases the load rapidly; with large field currents more slowly.

THE TRANSMISSION LINE

Since an ordinary transmission line possesses both resistance and inductance, it would appear to have characteristics similar to those of a synchronous machine. The synchronous machine, however, has armature reaction which the transmission line does not possess; and the transmission line has distributed capacity which the synchronous machine does not have.

So far the discussion has shown that a load on the synchronous motor causes the rotor to lag behind the rotating magnetic field. This is the same as the load causing an angular displacement between the applied and induced voltages of the motor. We have seen also that a load on a synchronous generator causes an angular displacement between its total induced electromotive force and its terminal voltage.

In the same manner, the load on a transmission line will produce an angular displacement between the generated and receiving voltages. Should the load be increased to the limiting value of this angle, instability will result just as in the synchronous motor, and the apparatus at the load end of the line will pull out of step with the synchronous machinery at the sending end.

The vector diagram for a short transmission line carrying a lagging power factor load is shown in Fig. 1. The capacity of the line has been neglected. In this diagran, I is the load current per phase, R is the line resistance per phase, and X, the inductive reactance per phase; V_r and V_g are the voltages at the receiving and generating ends of the line, respectively. It may be seen that the generator voltage V_g is equal to the voltage at the receiver, V_r, plus the impedance drop through the line. The power-factor angle at the load is θ_r and the power-factor angle at the generator is θ_g.

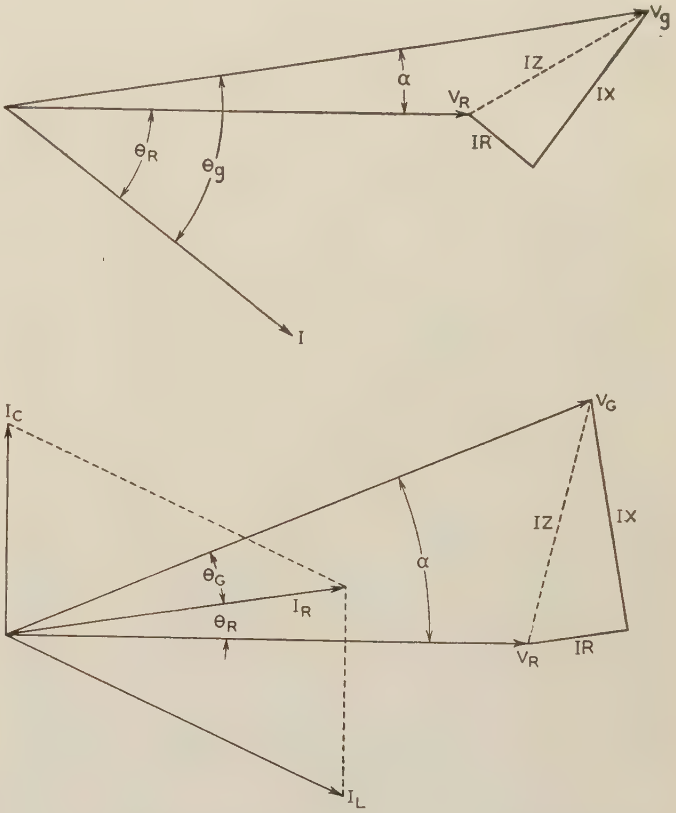

Fig. 1. Vector diagrams for a short transmission line (above) carrying a lagging power factor load; (below) a condenser load is added

Another important thing to note in this diagram is the angle α between the generator voltage V_g and the voltage at the load V_r. It can be shown that when the tangent of α is equal to X/R, α is nearly equal to 90 deg., and the line is then delivering its maximum power. In other words, when α approaches 90 deg., the line becomes unstable. (In actual practise, the limiting angle is somewhat less than 90 deg.)

Now suppose that a condenser is placed at the end of the line so as to raise the power factor; the vector diagram for this condition is shown also in Fig. 1:

The resultant current is now leading the receiver voltage but lagging the generated voltage V_g. The power factor at the generator has been raised, but at the same time the angle α has become larger than before, with the result that the limit of stability will be

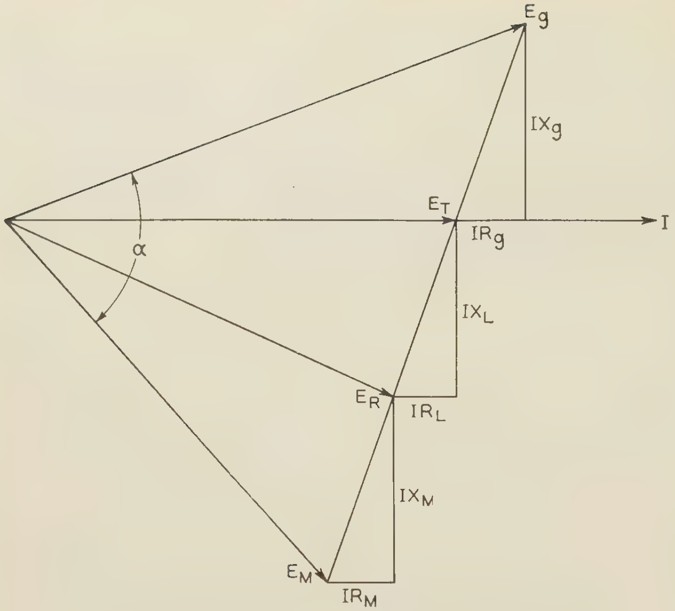

Fig. 2. Vector diagram for a synchronous motor connected through a reactive line to a synchronous generator

reached with a smaller value of current. In other words, the maximum power which the line can transmit has been reduced by adding the condenser load. Notice also that as the leading current in the line is increased, the receiver voltage may become larger than the generator voltage.

From the foregoing discussion and the diagrams in Fig. 1, it is obvious that the power limit of a transmission line can be increased by (1) decreasing the line impedance, (2) using generators and transformers of low impedance, or (3) using generators equipped with quick-acting relays which will cause the generator excitation to vary with the load.

Assume now that a synchronous generator and a synchronous motor are connected together through a transmission line having a certain amount of reactance; the vector diagram for these conditions will appear as shown in Fig. 2. Where, E_g is the total induced electromotive force of the generator, E_t is the terminal voltage of the alternator which is also the sending voltage of the transmission line, E_r is the receiver voltage of the transmission line which is also the terminal voltage of the motor, and E_m is the counter electromotive force of the motor.

When the angle α approaches 90 deg., breakdown occurs; but this breakdown takes place at a lower value of load and current than was the case with the motor connected directly to the generator terminals. With transformers added to the line, still greater reactance would be introduced into the circuit, and under these conditions the angle α approaches the stability limit more quickly with less load.

An oscillogram showing the voltage and current relations in a synchronous motor as instability occurred is shown in Fig. 3. The armature current of the motor may be seen to rise with load and then become unstable as breakdown takes place and the rotor drops out of step. The motor terminal voltage also may be seen to drop abruptly as the pull-out occurs. The field current is interesting because as the rotor slows down it has superimposed upon it an alternating voltage of increasing frequency.

It is now quite clear that an understanding of the problem of system power limits includes a detailed study of the characteristics of every piece of electrical apparatus involved, as well as the transmission line itself.

Another very important point to mention is the fact that raising the power factor may decrease the stability of the system, and that the power limit of a system may actually be greater for low power factor than for a higher power factor. Distributed capacity in the line may also lower the power limit, since it raises the power factor at the generator, thus reducing the field current necessary to produce rated voltage, at the same time decreasing the stability of the machine. This serves to emphasize again the important part which generator excitation plays in stability limits.

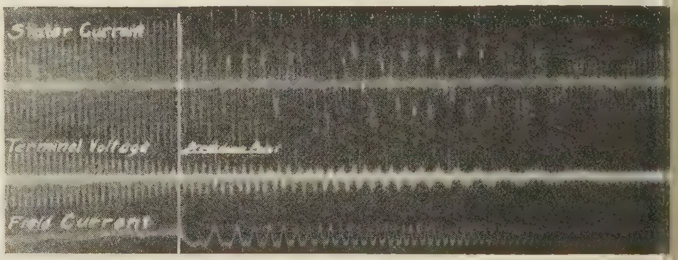

Fig. 3. Voltage and current relations in a synchronous motor at time of breakdown

Stability Tests Made

The effect of the generator and an inductive line upon the pull-out load of a synchronous motor is shown in Fig. 4. Data for these curves were the results of a test conducted as follows:

First a 25-hp. synchronous motor was connected to a bus of high capacity; the pull-out load and angular displacement was then noted. This pull-out load was 64 kw., and the angular displacement at the motor was 66 deg.

Then the motor was connected to the terminals of a

15 kva. generator and again the pull-out load was noted. This second pull-out load was found to be 32 kw., or one-half the first value, the displacement angle being only 39 deg.

In the third test the motor was connected to the generator through a reactive line. This time the pull-out load was only 18 kw. and the displacement angle 30 deg.

It may be seen at once that the introduction of the generator into the circuit had a much greater effect in reducing the pull-out load of the motor than did the transmission line. It is for this reason that most of the efforts to stabilize power systems are concentrated upon the generator.

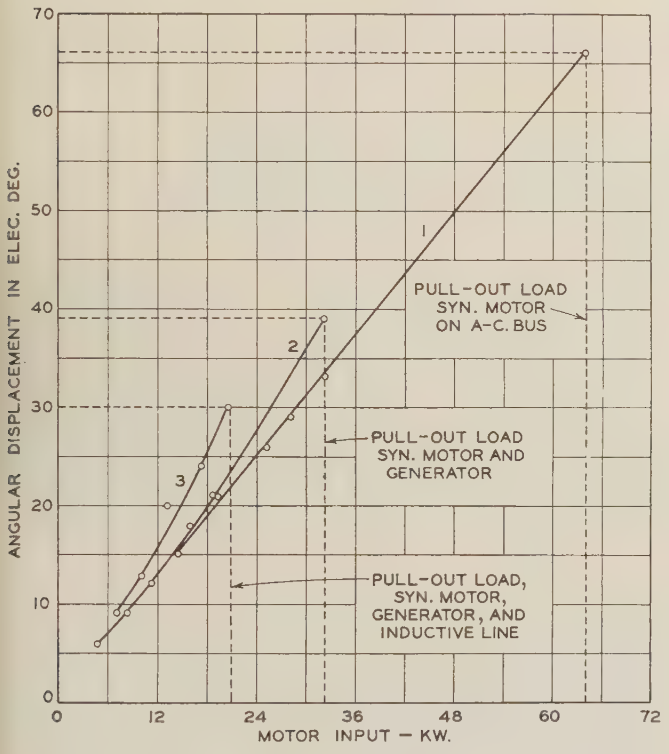

Fig. 4. Pull-out loads for a synchronous motor connected in various ways

MEANS FOR IMPROVING STABILITY

Several means for improving the stability of power systems in order to raise the power limits have been proposed or investigated. Some of these are enumerated as follows:

1. Vary the excitation of generators with the load.
2. Load the bus at the generating station with reactors to lower the power factor on the generators without lowering the power factor of the transmission lines. This would also allow for increased generator excitation, resulting in an increased system power limit.
3. Partially replace synchronous apparatus with induction generators and motors.
4. Lengthen air-gap of generators to increase degree of magnetic saturation.
5. Intermediate condenser stations may be placed at points along the line.

There is no doubt that the most important factor lies in providing generator excitation to follow rapidly any change in load. A new method of increasing the field current as the load increases has been investigated at the electrical laboratories of the University of Colorado with marked success. When the apparatus was devised it was first thought that the idea was entirely new; it was soon learned however, that a similar idea was being developed by the General Electric Company.

The new device acts to greatly increase the generator excitation as the load increases, regardless of what the voltage or power factor might be. A diagram of the apparatus is shown in Fig. 5. Here a generator is connected to a synchronous motor through a reactive line. In the line near the generator terminals are placed three current transformers with their secondary windings, Y-connected to the terminals of a small three-phase induction motor. When a load is thrown on the synchronous motor, the currents in the windings of the current transformers increase, thereby causing the rotor of the induction motor to produce torque in a counterclockwise direction. This lowers a contact into a water rheostat, decreasing its resistance and thereby increasing the field of the generator which enables the system to remain in synchronism. The device is extremely simple, and its efficiency has been demonstrated many times under all kinds of circumstances. A similar device to regulate the slip of large induction motors already is in use.

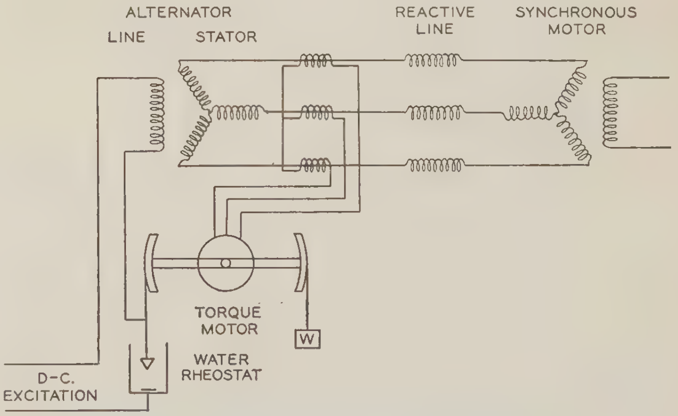

Fig. 5. Arrangement for enabling generator field current to follow rapid changes in load

Several tests have been made by over-exciting a synchronous motor; then loading it to the breakdown point. As already pointed out, the breakdown point under this condition is low, with no regulator of this kind in the circuit. With a leading power factor of 95 per cent, the breakdown point was found to be 22 kw., and the angular displacement 21 deg. Then the same test was repeated with the new excitation regulator. This caused the generator field current to be raised from 2.5 to 8.5 amperes as the load increased, and the breakdown point was raised to 25.5 kw. at an angle of 24 deg.

Another example might be interesting. By means of the over-excited synchronous motor the alternator was was loaded to capacity, whereupon an induction motor of the same rating as the alternator was thrown directly on the line; of course the system pulled out of step. This was repeated with the excitation regulator in the circuit, with the result that the system remained in step and the synchronous motor continued to carry its load as though nothing had happened.

Any scheme of generator field regulation which will, allow the excitation to follow rapidly any changes in the load as this system does should go a long way toward solving the stability problem.

The system just described has the added advantage of remaining operative even under badly unbalanced load conditions.

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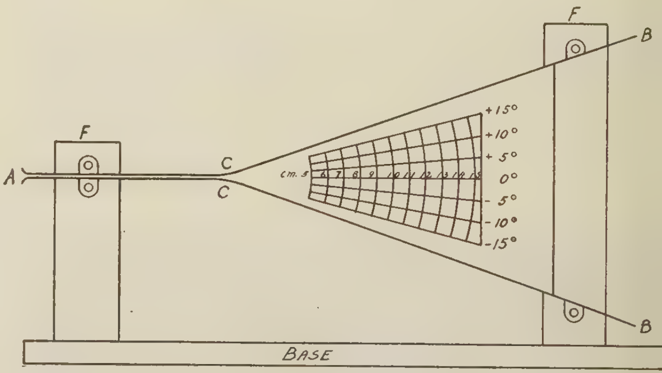
Determining the Flexibility of Mica Sheets

WITH the desire to make possible closer grading and duplication of flexible mica sheets, an apparatus called the "fleximeter" has been developed for the New England Mica Company by W. R. Mansfield of that company, and Willis A. Boughton of the Harvard College chemical laboratory.

This apparatus (see illustration) is a simple devic for measuring empirically the free bending length of sample strip of the flexible sheet that while in continuous motion downward under pull of gravity, cover a selected arc in a definite time. The following empirical specifications have been selected as giving convenient and rational values:

1. Test strip, 5 cm. wide, 20 to 25 cm. long, and 0.015 in. thick.
2. Horizontal position taken as 0 deg.
3. Arc over which fall is free, + 15 deg. to − 15 deg.
4. Arc over which time of fall is read, 0 deg. to − 10 deg.
5. Time of fall for free end, 10 sec.



Front view of "fleximeter" for mica testing

A test strip is inserted between the pieces *A C* (which are about 6 cm wide, front to back) is held at the *A* end with the left hand, and stretche against the upper strip *C B* with the right; it is then released at the *B* en and allowed to fall free. The length which will thus fall from zero to th − 10 deg. line in exactly 10 sec., is determined by trial.

This free length of the test strip which require exactly 10 sec. to fall from zero to − 10 deg., expresse in *millimeters*, is called the fleximeter number an represents the non-resilient flexibility of the sheet.

After the first test on any particular specimen, th strip is turned over and the test repeated. The piec is then turned end for end and another pair of reading taken. Thus four lengths are obtained, the average o which is taken as the fleximeter number. Data illustrating the method and its application to severa variety of plates are shown in the accompanyin tabulation.

FLEXIMETER NUMBERS OF FOUR FLEXIBLE MICA SHEETS

Sheet No.	Mm. lengths giving 10-sec. fall 1	2	3	4	Avg. length or fleximeter No
9	58	56	59	54	57
11	67	62	66	65	65
12	77	81	95	86	85
16	114	126	118	120	120

Differences in flexibility such as are indicated between sheets Nos. 9 and 11 could not be distinguished by ordinary inspection and handling; sheet No. 12 was apparently only slightly stiffer than these two, while sheet No. 16 would ordinarily be considered only a grade or two less flexible than the others.

A High-Speed Submarine Cable

Higher transmitting speeds than had been attained previously were made possible in 1928 by the installation of the high-speed loaded cable between Newfoundland and the Azores. Some of the design features and problems involved in duplex operation are described.

By J. W. Milnor and G. A. Randall

Fellow A. I. E. E. Non-Member

Western Union Telegraph Co.
New York

A SUBMARINE telegraph cable of a new type was laid in September 1928, connecting the Western Union Telegraph Company's cable station at Bay Roberts, Newfoundland, and Horta, Azores (See illustrations). This cable combines the facilities for duplex, or two-way operation inherent in non-loaded cable, with the high-speed characteristics of the new, loaded type. Tests on this cable have shown that a duplex speed of at least 1,400 letters per min. (42 cycles per sec.) simultaneously in each direction is now practicable. If operated simplex,—*i. e.*, in one direction only,—the speed is over 2,500 letters per min. It therefore provides the greatest message-carrying capacity of any existing transocean cable.

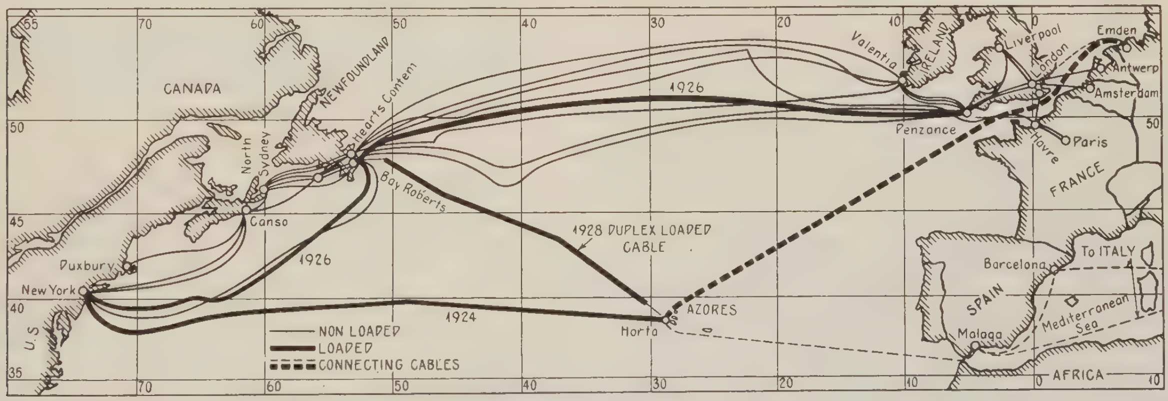


Fig. 1. Western Union cable system in the North Atlantic

The first long continuously-loaded submarine telegraph cable was laid in 1924; since then, eight other loaded cables of similar construction have been laid by various companies. These cables have several times the operating speed of non-loaded cables, but their electrical characteristics are such that they are much more difficult to duplex, and, therefore, have been operated simplex only. There are many situations, however, where duplex operation is decidedly advantageous, consequently it was inevitable that attempts should be made to develop a type of cable capable of high-speed duplex operation.

General Theory of Duplex Cables

In order to duplex a cable, it is necessary to provide at each terminal station a so-called "artificial line," the impedance of which must closely match or "balance" that of the cable throughout a range of frequencies from about half the fundamental signaling frequency up to about 1.6 times that frequency.

A loaded cable is more difficult to balance for three reasons: (1) There are larger irregularities in the impedance measured at different points; (2) the effect of such irregularities upon balance is more pronounced in a loaded cable; and (3) the inductance and effective resistance of loaded cable undergoes continuous, small variations in accordance with the changing magnitude of the signaling current.

Each of these difficulties may be reduced in importance by loading only the central portion, and suitably designing each section. For the non-loaded portion the duplex balance may have about the same high accuracy as has been customary in the past in non-loaded cables. In the part of the artificial line corresponding to the loaded portion, a duplex balance of a much lower degree of accuracy is sufficient.

Some of the various factors affecting accuracy and stability of balance, are: (1) The attenuation from end to end of the cable as measured at working frequencies; (2) the attenuation from end to end of the loaded portion of the cable; (3) the "current coefficient of inductance," *i. e.*, the fractional rate at which the induc-

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From "The Newfoundland-Azores High-Speed Duplex Cable," (**No. 31-12**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

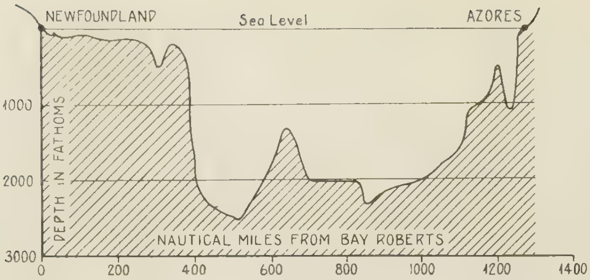


Fig. 2. Profile of ocean bottom route of the 1928 cable

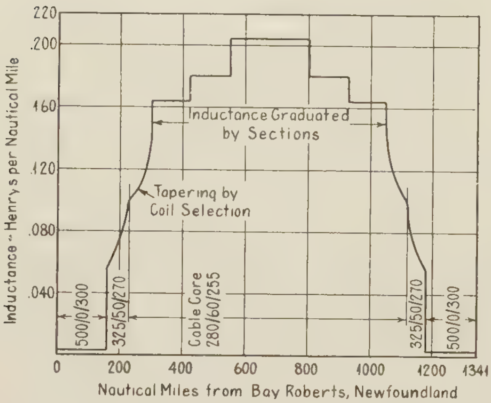


Fig. 3. Inductance of different sections of cable

tance of loaded cable varies with current; and (4) tapered loading.

DESCRIPTION OF 1928 CABLE

The total length of the cable is 1,341.2 nautical miles. Each non-loaded end portion is 160 miles in length; the heavily-loaded central section is 881 miles in length, while intermediate between these two types there are sections of lightly-loaded cable, each 70 miles in length. Further details of the design and electrical characteristics of each section are given in Table I.

TABLE I—CHARACTERISTICS OF CABLE CORE FOR DIFFERENT SECTIONS

Factory values per nautical mile, at 75 deg. fahr.

	Sections		
	Ends	Intermediate	Center
Weight of copper—lb	508	329	284
Weight of loading—lb	non-loaded	51	60
Weight of gutta percha—lb	303	275	258
D-c. resistance—ohms	2.34	3.60	4.18
Capacitance—μf	0.357	0.344	0.342

The loading throughout the central and intermediate portions is Mumetal wire supplied by the Telegraph Construction and Maintenance Company, Ltd., of London. This material is similar to permalloy. A permeability range from 2,000 to 6,800 was obtained in different sections of the cable by controlled variations in the annealing process. The average values of inductance are given in Fig. 3.

In order to reduce extraneous voltages picked up in shallow water it is customary to carry a second and sometimes a third core in the sections near the ends. At Bay Roberts the receiving sea earth is 50.1 nautical miles long and is grounded to the cable sheath through a resistance of 160 ohms. At Horta, Azores, the corresponding length is 2.39 miles and is grounded directly to the sheath.

CABLE TESTS

Various tests were made on the cable both during manufacture and also after it was laid. The total d-c. resistance is 4,521 ohms; the total capacity 463 μf.

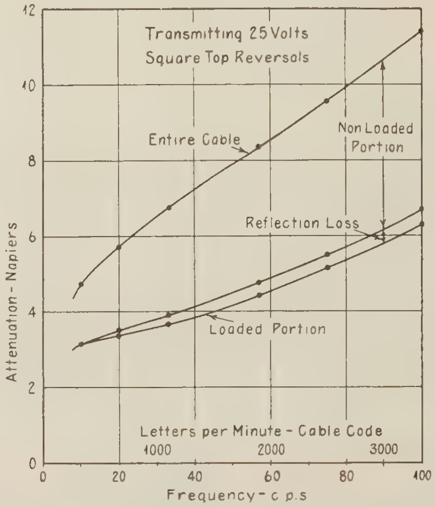


Fig. 4. Attenuation of laid cable

The results of some of the attenuation tests with square-topped transmitting waves are shown in Fig. 4.

The time of propagation of signals over the cable is 0.235 sec. at 60 cycles. It has been estimated that during the process of laying, the mechanical strains placed upon the cable caused an average of about 13 per cent loss in the inductance.

ARTIFICIAL-LINE EQUIPMENT

An essential part of this cable project has been the provision at each cable station of an adequate artificial line for completing the Wheatstone bridge arrangement which is necessary for duplex operation. The present equipment is somewhat more complicated than in the case of the usual artificial line for low-speed cables. In addition to resistance and capacity elements, the present equipment includes means for simulating the inductance of both loaded and non-loaded portions, the eddy-current losses in the loading, sea-return losses, and dielectric losses. A compensating arrangement is introduced to prevent "filter oscillations" between the condenser and inductance units.

As in the case of the cable itself, the change of inductance with current in the coils of the artificial line was given consideration and was held to a relatively small amount. It was also necessary to exercise unusual precautions to guard against the effects of temperature changes and of pick-up of extraneous disturbances by the coils.

It has been estimated that for transmission of telegraph characters, the impedance of the artificial line matches that of the cable to an accuracy of roughly one part in 4,000, and for sine waves in the range between 35 and 55 cycles, better than one part in 7,000.

Merits of Simplex and Duplex Cables

In determining the kind of cable facilities best suited for handling telegraph traffic between two given areas, there are many factors which must be considered; among these are the length of the circuit, the desired message capacity, the relative amounts of urgent and deferred traffic, the difference between the loads in each direction, the difference in time between the terminal areas, the nature of existing cable facilities, and the handling of traffic in case of failure of one or more cables.

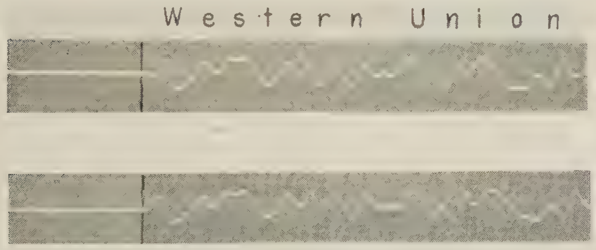


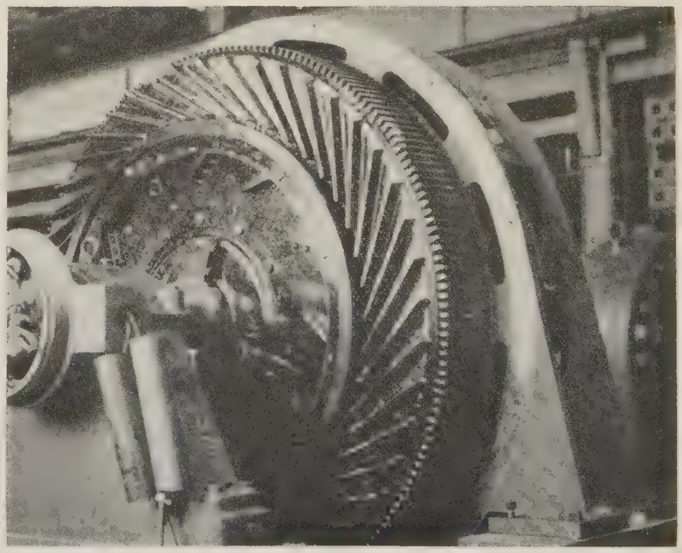
Fig. 5. Cable-code signals as received at Bay Roberts showing in the upper record simplex westward transmission, and in the lower record duplex eastward and westward transmission

Where the load is sufficient to justify only a single cable, and the difference in time between the terminals is not excessive, the duplex type usually offers the most convenient solution. If the terminals are so located that there is a considerable time difference, the simplex cable has the advantage. Where the amount of traffic is enough to justify two or more cables, there are various possible solutions; in some cases it is probable that a combination of simplex and duplex cables is the best solution. It also appears probable that neither the simplex nor the duplex cable has as yet reached its limit of economical development; hence, it is hardly practicable at this time to give a final answer to these questions.

Metal-Clad Synchronous Motors Latest Thing for Nitrate Plants

WORKING in an atmosphere of fine nitrate dust, the 250-hp. Westinghouse synchronous motor shown under construction in the accompanying illustration, obviates the usual danger of nitric-acid damage to its windings. Built to fit their job, the vulnerable parts of these motors are metal-clad and in addition are supplied with a slight static pressure inside to prevent the harmful dust from leaking in. Inclined fins on the metal enclosure not only throw off heat, but guide along the most efficient route the cooling air supplied by the fan on the rotor. Without these odd-looking fins the operating temperature of the motor would be much higher. These motors are designed to operate on 550-volt, 60-cycle circuits and have a synchronous speed of 450 r. p. m.

Although built to meet many requirements which do not handicap the usual open synchronous motor, these motors are only about one-fifth larger than the ordinary type. Besides being protected from nitrate dust, they produce 120 per cent starting torque and 100 per cent pull-in torque—about twice the usual values. Rated at 90 per cent leading power factor these motors will carry full mechanical load while also furnishing power-factor correction. And although they work a mile above sea level in rarefied atmosphere, the temperature rise is but slightly more than usual, being rated at 55 deg. cent. for El. 5,000 ft.



One of the 250-hp. synchronous nitrate-crusher motors built for the Anglo Chilean Corporation. Note the metal enclosures protecting the windings; cooling fins serve also as guide vanes for circulating air

Noise—

With America becoming "noise conscious," electrical engineers are finding it necessary to devote increasing attention to the reduction of noises caused by electrical machinery. Progress in this direction, both in specially designed instruments and in mitigative measures adopted, is indicated in the accompanying articles.

NOISE is a comprehensive term which includes almost all sounds except music and speech, and covers the entire audible range both in loudness and frequency. Noises set up by electrical machinery are caused chiefly by vibration of the machines as a whole or in parts, and are usually recurrent and approximately steady as contrasted with the random character of ordinary street noises. The resultant noise perceived by the ear, however, is in the main a mixture of two components, one emanating directly from the machines and the other radiated from the floor and walls of surrounding enclosures.

In order to control noise a thorough understanding not only of the causes but also of the mode of transmission of noise is necessary. It is in this aspect of the problem that accurate measurements are especially helpful and with instruments now available information may be obtained which will serve as a basis for changes in machine design. There is a tendency, however, to reduce the size and weight of machines due to the improved electrical and magnetic materials now available. This complicates still further the already difficult problem of designing quiet machinery, since the lighter structures are more susceptible to vibration.

Difficulties in Measuring Machine Noise

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WHEN a new and useful machine is first introduced, nobody thinks much about possible refinements. Thus when electric motors were first used, reliability was the essential quality. Soon afterward price became of importance; still later, efficiency was considered. At the present time attention is being turned to noise and the point has now been reached where the need of adequate means for noise measurement is felt. At present the intensity of a noise is stated about as accurately as the Irishman's reply that a certain object was "about as large as a lump of coal."

Two distinct types of measuring devices are needed: One, if possible, to give an indication of the intensity of a sound with a single reading in the same manner in which an ammeter gives at once the current in a circuit; the other, to make possible the analysis of a sound into its component parts in much the same manner that the components of a current can be analyzed by means of the oscillograph. The first type will be useful to the manufacturers and users of machinery in determining quickly and easily whether a machine comes within certain prescribed limits of quietness. The second type will be useful to the machine designer by enabling him to determine and eliminate the sources of noise.

DIFFICULTIES OF THE PROBLEM

When an attempt is made to develop an instrument which will give an objective indication of the degree of noise from a given source, serious difficulties are encountered. Unfortunately the effect upon the human ear is not directly proportional to the physical intensity of the sound. A sound of very high pitch, for example, cannot be heard at all; and the same is true of sounds of very low pitch. Moreover the range over which the ear can hear varies with different persons and at different times. The problem is further complicated by the fact that what is really desired is to find out how disagreeable a certain noise is regardless of its intensity.

Another difficulty arises from the fact that in an ordinary room not only is the sound itself heard but also many reflections of that sound. A sound indoors at a certain distance may easily produce ten times the effect of the same sound at the same distance in open air. Moreover in any ordinary room the sound will be focused at certain points and consequently will be much louder there than at other parts of the room, and sometimes even louder than at the object emitting the sound. One obvious remedy is to make all tests in sound-proof rooms. But while this is possible in the laboratory, serious difficulties would be encountered in applying the method to routine production. A method

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From "Measurement of Noise in Electrical Machinery," (No. 31-68).

a factor in Machine Design *and* Operation

THE articles on these and the following twelve pages comprise abstracts of a noise abatement symposium presented at the A. I. E. E. Rochester, (N. Y.) District meeting. These consist of (1) a general review of the difficulties involved in obtaining suitable noise measurements, by B. F. Bailey, University of Michigan; (2) a description of a new sound meter which simulates the response of the human ear, by T. G. Castner, Bell Telephone Laboratories, E. Dietze and R. S. Tucker, American Telephone and Telegraph Company, and G. T. Stanton, Electrical Research Products Inc.; (3) a résumé of the measurement of machinery noise featuring a new audio noise meter, by H. B. Marvin, General Electric Company; (4) a study of the noises in induction regulators, by J. P. Foltz and W. F. Shirk, Westinghouse Electric & Manufacturing Company; (5) a discussion of magnetic noises in synchronous machines, by Quentin Graham, Sterling Beckwith, and Frank H. Milliken, Westinghouse Electric & Manufacturing Company; (6) some interesting results obtained with elastic supports, by E. H. Hull, and W. C. Stewart, General Electric Company; (7) an outline of present means of reducing substation noises, by E. A. Bishop, Commonwealth Edison Company.

used with some success is to provide a very large rotating vane to break up reflections and prevent them from concentrating at any one point.

As previously indicated there is need also for some means by which sound can be analyzed into its various components and the intensity of each of these determined. One method now in use consists in using a microphone to pick up the sounds which in turn are amplified by vacuum tubes and then passed through a variable filter. Since only one component passes through the filter at a time, it can thus be measured by a galvanometer or similar indicating device, a method, which while obviously slow, gives complete information in regard to the sound produced and is unquestionably of great value to the designer.

ORGANIZATIONS INTERESTED

Several manufacturers of various types of machinery have become greatly interested in methods for measuring accurately and quickly the noises produced by their products. In the past five years approximately $250,000 has been spent upon such projects at the University of Michigan alone; methods have been devised for measuring the noise produced in ball and roller bearings, gears, electric carpet sweepers, and other devices; instruments have been constructed and are now being used in routine production in several factories.

Certain national societies, among them the National Electrical Manufacturers Association and the American Society of Mechanical Engineers, have become interested in the problem and have appointed committees to consider the subject. The committee of the former organization was instructed first to find or devise a method of measuring the noise produced by electrical machinery; then, when such a device has been found, to formulate standards of allowable noise for this machinery. Some of the difficulties in the first part of this problem have already been indicated. Considering even the enormous variation in horsepower, speed, frequency, and number of phases, of electric motors alone, it will be apparent that the difficulties of the second part of the assignment are no less than those of the first part.

CONCLUSIONS

It is evident that the American people as well as the manufacturers of electrical machinery are becoming "noise conscious." Great progress has been made within the past few years in devising means for measuring noise as well as improving machinery so that it will be less noisy. Although the difficulties of the problem are great, there is reason to hope that in the near future some device will be perfected to give an immediate indication of the effect of any given noise upon the human ear. After all, what is desired is to eliminate noise. But with such an instrument available progress will be much more rapid for a definite measure of noise will then have been achieved in place of the present imperfect estimate based entirely upon personal judgment.

A New Meter for Noise Analysis

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A SOUND METER has recently been developed in the Bell System, which measures acoustic noises and sounds in general. The aim has been to have its indications accord with present information on the response of the ear as far as practicable in a simple portable device. The response of the meter to sound impulses, in general an important part of noise, has been carefully considered. There is also under development an attachment to analyze sound both on a single-frequency and band-frequency basis.

The meter consists of a sound-pick-up device to convert acoustic into electrical energy, a multi-stage vacuum-tube amplifier, a calibrated gain control to measure sound levels over a range of 90 db. (corresponding to a range of 1,000,000,000:1 in input powers), an electrical network to weight different frequencies in a manner similar to that in which they are weighted by the ear, a rectifier and visual indicating meter which responds in a manner similar to the ear, and means for over-all acoustic calibration.

Calibration is in terms of physical units rather than in some other terms which might depend upon the "personal equation." The sound meter is calibrated in terms of a 1,000-cycle pressure of 0.001 dyne per sq. cm. in a free progressive wave which pressure is called the "reference sound level." Sound levels measured are expressed in decibels above this reference point. For a 1,000-cycle tone, this reference level is somewhat above the minimum threshold of audibility of the average observer.

NOISE AND HEARING

In the design of a meter of this type, certain physical characteristics of noise and hearing must be considered in order that its indications will be correlatable with noise effects. These effects are known to vary with time in many different ways but the important part played by the sharply peaked wave forms of some noises generally is not fully realized.

Principal characteristics of hearing taken into account in the design of the meter are those relating the sensation of loudness to the physical properties of a sound, such as intensity (sound power passing through unit area), frequency, duration, and complexity of wave shape. This subject is not discussed here as a great deal has already been published regarding it.

DESCRIPTION OF SOUND METER

Usefulness of a device for general noise measurements depends largely upon portability, as in most cases the meter must be taken to the location of the noise. For this reason, therefore, the sound meter has been made small and light. Fig. 1 shows a schematic layout diagram while in Fig. 2 is shown an experimental model of the meter. Batteries are contained in a separate box but both units together can be carried easily by one man.

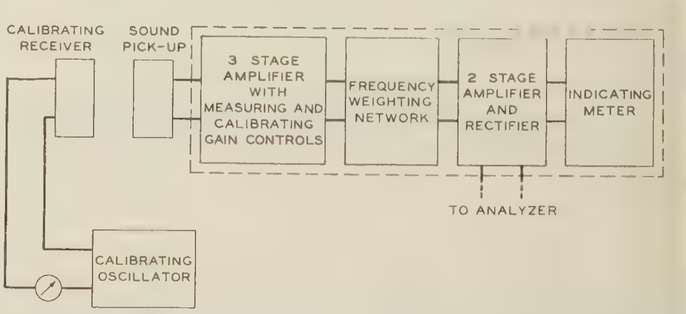
CALIBRATING RECEIVER
SOUND PICK-UP
3 STAGE AMPLIFIER WITH MEASURING AND CALIBRATING GAIN CONTROLS
FREQUENCY WEIGHTING NETWORK
2 STAGE AMPLIFIER AND RECTIFIER
INDICATING METER
TO ANALYZER
CALIBRATING OSCILLATOR

Fig. 1. Layout of noise meter showing arrangement of component parts and calibrating apparatus

The meter is capable of measuring noise magnitudes from about 10 to 100 db. above reference sound level, and covers a frequency range from about 50 to 10,000 cycles per sec. It is direct reading in db. above reference sound level, and weights noise components at different frequencies approximately according to the 40 db. curve of Fig. 3. An adjustable frequency-weighting is not thought necessary since it would not appreciably change the results of more than a small proportion of the measurements.

A full indication on the meter is obtained in about 0.2 second. The fact that a 0.2-sec. response approximately simulates that of the ear can be demonstrated by watching the movements of the needle of a meter having this response and at the same time listening to the variation of the noise. In such a test the visual and aural impressions are approximately synchronized. Measurements of certain noise impulses taken with this meter and with a meter requiring about 5 sec. to reach full indication gave differences in the readings on the same impulses amounting to about 15 to 30 db.

The output circuit of the sound meter follows approximately a "square law;" that is, the meter reading is about the same for a sinusoidal voltage as for a steady

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From "Indicating Meter for Measurement and Analysis of Noise," (**No. 31-80**) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

complex voltage of the same r. m. s. value. Thus the reading is a function merely of the average impressed power and not of wave shape. The reading should preferably not depend upon phase relations, which are affected by phase shift in the meter.

The meter has been designed so that its readings with negligible error for common noises are proportional to the input level over the whole 90 db. range provided. It is practically completely shielded against electrostatic fields. The shielding provided against stray electromagnetic fields is believed to be sufficient for practical purposes.

CALIBRATION

Primary absolute calibration of the sound meter was made by placing the sound pick-up in a 1,000-cycle free progressive wave at a point at which the pressure was determined from Rayleigh disk measurements.

Great care has been taken to make the meter electrically stable. In addition, in order to verify in the field that the meter is reading correctly, a means for making an over-all acoustic calibration has been provided. The apparatus for this secondary calibration consists of a stable telephone receiver, a 2,000-cycle oscillator, and a means for coupling the receiver to the sound pick-up. This calibration may be made in a few seconds.

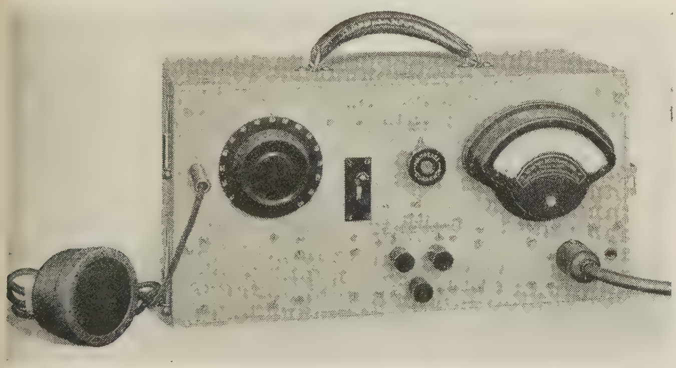

Fig. 2. An experimental model of sound meter with pick-up device at the left

An attachment to the sound meter is now under development, by means of which either a quantitative frequency analysis of a sound or a measurement of the amount of sound energy in various frequency bands can be made easily and quickly.

USES OF SOUND METER

The sound meter is applicable to a great many acoustic problems. It is necessary, however, to take care that sounds other than those under investigation do not affect the measurements, and to take account of the test conditions in the interpretation of the results, *i. e.*, the acoustic properties of the surroundings, the location of the pick-up with respect to the noise sources, and other influencing factors.

This meter can be used to make noise surveys; to aid in ascertaining desired levels of noise in various cases, and determine when these levels have been met; to measure machine noises; to measure noise in residential neighborhoods where power substations may be installed; and to measure sounds other than noise (in recording and broadcasting work, for example, to determine optimum levels and sound distributions).

With the analyzer more detailed information will be obtainable than is furnished by over-all sound measurements alone. This device will aid in determining whether an undesired sound will be covered up by the general noise, or whether a signal will be audible through this noise. Determination of the frequencies of noise components permits selection of the sound-absorbing material most effective in reducing noise. Determination of the noise components of a machine may yield data as to the contribution of each individual noise source in the machine; such data can then be applied in the redesign of machines to reduce noise. The control of uniformity of manufactured products by means of acoustic measurement also offers a potential field of application for the sound meter.

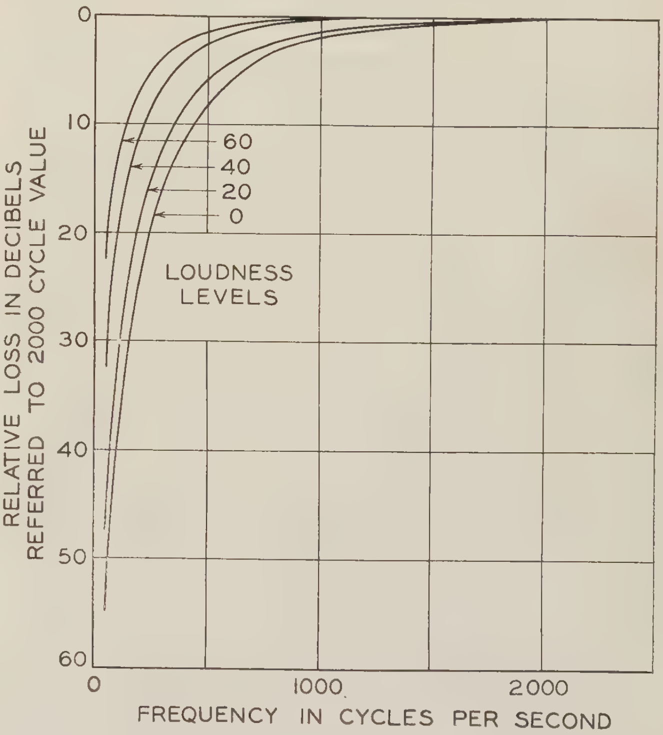

Fig. 3. Frequency weighting curves for equal loudness

By means of a suitable electrical input the sound meter may even be used in certain cases to measure electrical levels or to analyze electrical quantities; but it is believed that this new meter will prove of greatest value in the study of noise and sound problems which are almost daily increasing in variety and complexity.

Magnetic Noise in Synchronous Machines

By
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MAGNETIC NOISE in synchronous machines, particularly those of the low-speed class, has been a source of annoyance to both designers and operators, but literature on the general subject of noise is notably free from any discussion of the specific causes of noise in this type of machine. In this article an attempt is made to point out some of the causes of this noise and to show the extent to which they may be controlled by the designer.

When the noise problem in synchronous machines was first investigated several years ago there was a great deal of speculation concerning the particular part of the machine that produced the principal vibration. Suspicion pointed to the stator teeth, the overhanging tips of the poles, and the poles as a whole. It finally became evident, however, that one of the principal sources of noise was the vibration of the stator as a unit.

The most frequent cases of stator vibration arise from flux distributions which, because of unequal magnetic pull on all axes, make the stator to assume an elliptical shape. This condition requires, in effect, a two-pole flux distribution superposed on the normal distribution. It will be shown later that there are several ways in which such a flux distribution may be set up. It is also possible to have a four-pole (or more) distribution which will tend to distort the stator at four (or more) points. Since the stator structure is much more rigid with respect to these forces than to the two-pole force, they are not such frequent sources of trouble.

Rotor vibration takes more forms than stator vibration. One possibility is for the rotor rim between arms of the spider to move in and out, either in phase or 180 deg. out of phase, with the segment between the succeeding spider arms. Another possibility is for the poles to vibrate circumferentially. A third mode of vibration occurs when parts of the spider rim vibrate axially. This last type of motion resembles that occurring in gears.

Under certain conditions it is possible to have magnetic forces tending to pull the rotor out of center. This requires a distribution of force having only one wavelength in the circumference of the machine. It might be called by analogy a one-pole distribution and is similar to what occurs when the air-gap is unequal. Such forces are found in induction motors[1] (for numbered references see bibliography) but would occur in synchronous machines only if odd numbers of slots were used. Since the number of slots in synchronous machines is almost invariably an even number, especially in large machines, this type of vibration rarely occurs and will not be discussed here in detail.

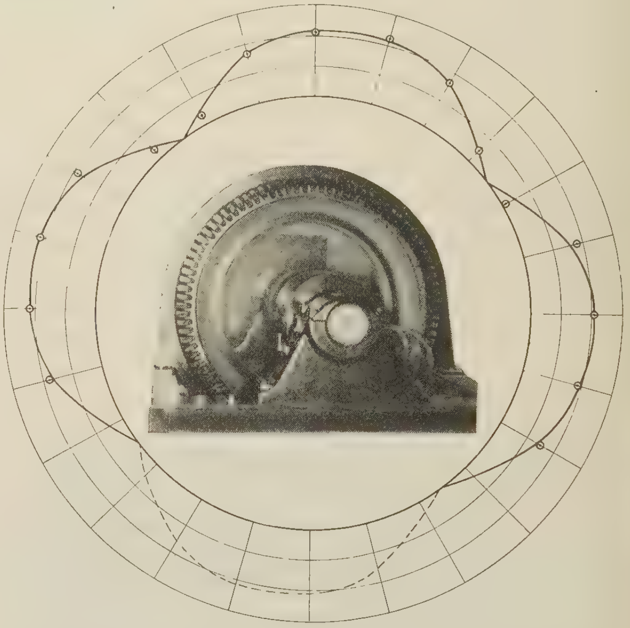

Fig. 1. Pole-frequency vibration around the circumference of the stator. The motor in the center is correctly oriented with respect to the measurements

Two important classes of noise or vibration with reference to frequency have been noted; namely, (1) tooth frequency noise, usually occurring at no-load and independent of armature current, but sometimes proportional to or increasing with it; (2) pole-frequency noise or noise of twice the line frequency which depends upon the armature current and is thus much lower in tone than the other type of noise.

It is realized that noises of other frequencies may exist but as they are relatively unimportant they will not be considered here.

TOOTH-FREQUENCY FORCES

In order to explain the cause of tooth-frequency noise, it is convenient to consider the change in flux of a single pole as it moves over one stator tooth pitch. Clearly there is some point where the flux is at maximum and some point where it is at minimum; thus the flux in each pole rises and falls slightly each time a tooth pitch is traversed, and the magnetic pull between that pole and the stator goes through a corresponding cycle. Assume for example that a machine has 14 poles and $5^1/_7$ stator slots per pole; it is evident that if Pole No. 1

From "Magnetic Noise in Synchronous Machines," (**No. 31-78**) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

has maximum flux at a given instant, Pole No. 2, $^1/_7$ tooth pitch from the same relative slot position will have slightly less flux. Each succeeding pole will have a little less flux until the minimum is reached, after which there will be a gradual increase. Thus there will be two areas diametrically opposite having high flux density and two areas on an axis at 90 deg. to these, having low density. The result is a higher magnetic pull along one axis and a tendency to give the stator an elliptical shape.

It now remains to see what happens to the magnetic pull or stator distortion as the field member rotates; using the given example, it may be seen readily that when the rotor has moved $^1/_7$ tooth pitch, the point of maximum density has shifted from Pole No. 1 to Pole No. 2. When a tooth pitch has been traversed, the point of high density has moved seven pole pitches as measured on the rotor. With reference to the stator, the distorting force has moved seven pole pitches plus one tooth pitch. Thus it may be seen that a given point on the stator goes through a complete cycle from maximum pull, through minimum pull, and back to maximum, while the rotor moves slightly less than one tooth pitch.

In order to have a gradual distribution of density or pull over a group of adjacent poles, certain fractional numbers of slots must be used. With certain other fractional numbers it is shown that the poles having high density at a given instant are so alternated with poles of low density that the frame deformation is of a different form. The curves of magnetic pull plotted against pole position in these cases have two or more maximum points but due to the greater rigidity of the frame, a pull of short wavelength is usually unimportant. There may be a small component of pull which has a two-pole distribution, but its magnitude is so much less than in the previous case that there is seldom any trouble from noise.

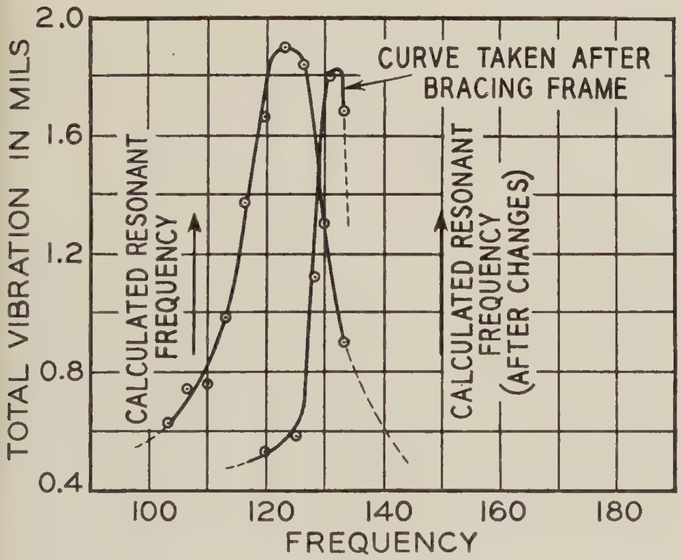

Fig. 2. Resonance curves for pole-frequency stator vibration before and after bracing the motor frame

POLE-FREQUENCY FORCES

It has been previously noted[2] that the armature m. m. f. waves of machines having fractional slot windings contain components of low-harmonic order. With certain slot arrangements there may be a component wave of m. m. f. and flux having a two-pole distribution superposed on the main distribution of flux, which will cause elliptical distortion of the stator just as in the case described under no-load noise. In this case the two-pole field travels at the synchronous speed of a two-pole rotor. Similarly, a sub-harmonic having a four-pole (or more) distribution may distort the frame at four (or more) points and cause vibration. In all cases the frequency will be twice that of the supply circuit since the rate at which poles of the superposed distribution pass a given point on the stator is the same regardless of the number of poles.

While it is convenient to start from the assumption of a single two-pole component of armature m. m. f. in describing the effect of a two-pole pull, this simple type does not complete the story. When any two components of flux exist, differing in harmonic order by two, there will be a resulting modulated wave which gives the same effect as a simple two-pole distribution.[3] When the order of magnitudes is examined it is found that these modulated waves are really the important ones since in some cases the several components may combine in such a way as to partly cancel one another, while in other cases they add to form a higher total.

The elimination of any one unwanted harmonic can be accomplished by changing the coil grouping[3] in two relatively simple ways: (1) by cutting out coils the electrical position of which coincides with the vector position of the harmonic to be eliminated; or (2) by shifting coils from one phase group to the next adjacent group in such a way that the troublesome harmonic is

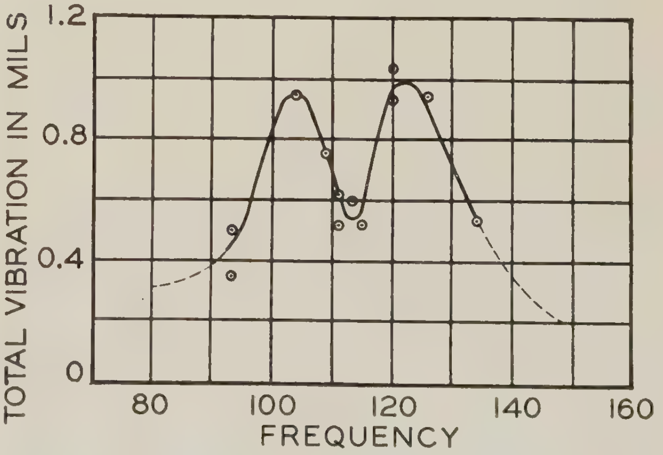

Fig. 3. Resonance for pole-frequency stator vibration showing dip in curve due to an end bell on motor frame

decreased without appreciably reducing the terminal voltage of the machine.

The existence of various forces tending to distort the machine has been established and it has been pointed out that the most serious cases of trouble arise from a two-pole pull which forms a single rotating ellipse since forces distributed in this way produce the greatest deflection. Experience, however, seems to show that nearly all cases of objectionable noise occur when there is resonance between the magnetic forces and some part of the mechanical structure. For this reason even the four-pole (or more) force distribution may result in trouble if the necessary resonant condition exists.

MECHANICAL ASPECTS

It may not be entirely obvious that a rotating deflection of the stator can be affected by resonance; it can be shown, however, that the rotating pull or deflection may be considered as the result of two stationary pulsating pulls which are 90 deg. apart in space and time. Thus resonance to a traveling elliptical deflection is quite possible although in practise one of these components is usually damped to some extent by the frame supports.

Tests made on a number of machines have shown that usually resistance to a distortion in the plane of the laminations is entirely dependent upon the frame or clamping plates and not upon the laminations. The laminations become so much dead weight attached to the frame but add nothing to its stiffness. A formula developed by Timoshenko[4] for simple rings has been applied to complete stators in a number of cases and has given useful results, as shown by the comparison between calculated and test results in Fig. 2.

While it has been shown that stator vibration is of consequence only when there is a force tending toward elliptical distortion of the frame, rotor vibration may be set up also by a periodic variation in the magnitude of the normal radial gap force, such as that occurring in integral slot machines.

Rotor resonance is affected so much by the rotor arms that it is not susceptible to such accurate calculation as the stator. Two formulas,[5] however, one for a section of rim pivoted at both ends and one for a section of rim fixed at both ends, have been found useful in giving the probable upper and lower bounds of resonant frequency for radial vibration.

A formula for the resonant frequency of gears with different modes of rim vibration is also available[6] and has been found useful but requires a great deal of empirical correction when applied to plate spiders.

Tangential vibration of the stator teeth is often throught of as the simplest and most probable form of mechanical vibration causing tooth frequency noise. If it be agreed that resonance is necessary for appreciable tooth motion, then almost all machines are out of the range where tooth resonant frequency approaches tooth frequency. The assumption that resonance is essential is justified by past experience and from a consideration of the stiffness of the teeth appears reasonable.

Results of several vibration tests of machines having pole-frequency vibration are shown in the accompanying illustrations. Measurements were made by amplifying the resistance variations in a phonograph pick-up the needle of which followed the motion of the frame. The accuracy of this method is indicated by the consistency of the test results.

TEST RESULTS

Variation in the amplitude of the vibration at different points around the circumference of a synchronous motor is shown in Fig. 1. (The nodes could be located easily by feeling the frame.) Measurements were made on the back of the punchings half way between the ends of the core. The results, however, would have been the same had they been made at any point on the same axial line.

In Fig. 2 may be seen the change of vibration amplitude as the supply frequency was varied, and the calculated resonant frequency for the motor frame. In making the calculation the punchings were added as dead weight but the armature copper was not included since it is probable that the slot clearance, flexibility of end windings, and damping effect of insulation may cause the effective mass to be zero or even negative. Similar tests were made after the machine was braced to add stiffness to the structure, the results of which also appear in Fig. 2. The reduction in vibration at the operating point (120-cycle) is worthy of note. The frame of this machine was not weak in comparison with frames of similar sizes and types but happened to have a natural period which gave unfortunate results.

In Fig. 3 is shown an exceedingly interesting curve with a dip in the center which was found to be due to end-bell resonance at that point. The violent oscillation of the rather light end-bells absorbed sufficient energy to decrease the frame vibration at what otherwise would have been its region of greatest amplitude. This illustrates the difficulties that face the designer in trying to predict his results, since calculation of the resonant point of a complex structure like an end-bell is practically impossible and since its likelihood of setting up objectionable overtones is great.

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Elastic Supports for Rotating Machinery

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NOISES ORIGINATING from electrical machinery are of two general types, namely, direct air noise, and noise transmitted through the machine foundations to the framework of the enclosing structure. (A. L. Kimball, *Journal of the Acoustical Society*, Vol. 2, No. 2, Oct. 1930, pp. 297-304.) Disturbances of the latter type often may be reduced by a properly designed elastic support between the machine and building.

Elastic supports can be made to isolate two types of disturbance; (1) shocks of any frequency typified by the automobile-spring suspension; (2) vibration of one or several known and constant frequencies. The supports described in this article fall into the second class and their function is to *isolate* not *absorb* vibration.

Effects of such a support may be demonstrated with the apparatus shown in Fig. 1: The mass M constrained to move in a vertical direction is supported through a spring k from the piston P which moves through a constant amplitude in approximate simple harmonic motion; M may be said to be elastically supported. At very low speed the weight moves through the same amplitude and in phase with the driving member. As the speed is increased the amplitude becomes larger, reaching a maximum at critical speed, then reducing as the speed is raised still more. At very high speed the weight appears to stand still in space. From this simple experiment it may be seen that the elastic support is not useful until a speed well above the critical point is reached.

In the case of an elastically supported machine "transmissibility" may be defined as the ratio of the force transmitted to the foundation to the disturbing force impressed on the machine. Fig. 2 shows that an elastic support is not beneficial until the ratio of impressed frequency to natural frequency of the system is greater than 1.41, and that when damping (frictional resistance to motion) is introduced the effectiveness of the support is lessened. See curves marked $b = 0.5$ and $b = 1.0$.

Values of transmissibility, beyond the speed range given in Fig. 2, and with zero damping, are given approximately by the square of the ratio of the natural frequency to the frequency of the impressed force.

MATERIALS AVAILABLE

Of the materials available for elastic support, such as metal springs, rubber, cork, felt, and gelatinous substances, a rubber compound containing a high percentage of pure rubber is at present found to be most suitable. Only small volumes of the material are necessary, the natural life is fairly long, damping is small, and protection from oil usually may be arranged. Once the elastic properties of rubber are understood, supports may be designed for nearly any combination of stiffness.

Noise and vibration of machines which may be transmitted through the foundation, and which may be isolated by an elastic mounting, fall into three general classes:

1. Vibration due to unbalance.

This occurs at rotational frequency which is usually below the audible range and hence does not cause noise directly, but may cause objectionable vibration of the foundations, resulting occasionally in rattles.

2. Bearing and brush noises.

Journal-bearing noise is negligible as is also brush noise in slip-ring motors. Ball or roller bearings may cause an objectionable disturbance.

3. Noise due to magnetic forces.

These forces are the greatest source of noise. In a-c. machines the fundamental noise frequency is twice the applied electrical frequency or 120 cycles for 60-cycle machines. Harmonics of this fundamental frequency and other high frequencies also occur but are of relatively less intensity.

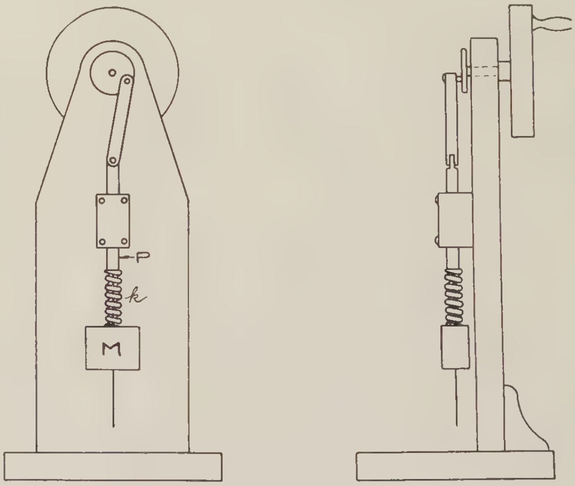

Fig. 1. Apparatus for demonstrating the operating principles of elastic supports

Elastic mountings capable of isolating this noise and these vibrations usually do not constitute a simple system, since in general there are six natural frequencies of the machine on its mounting. Mathematical expressions giving these frequencies have been developed and used to verify and predict resonances observed in elastically supported machines. The elasticity of the mounting must be adjusted to the machine so that none

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From "Elastic Supports for Isolating Rotating Machinery," (**No. 31-76**) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

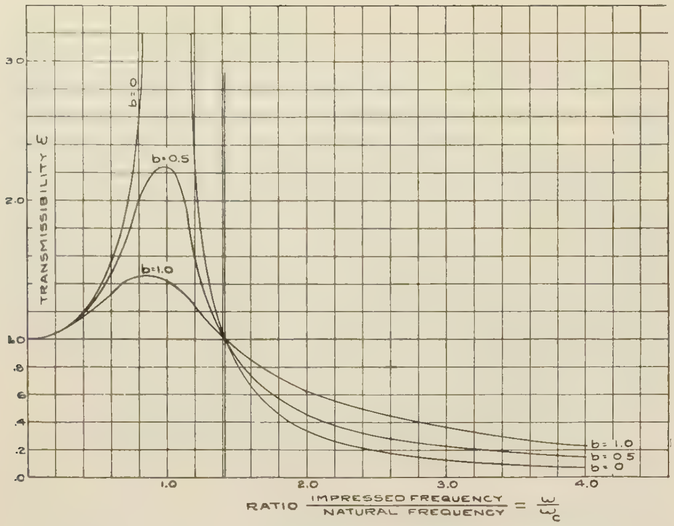

Fig. 2. Transmissibility curves for different damping constants

of these resonant frequencies coincide with that of any disturbing force, for should this occur both the vibration amplitude and the transmissibility would become large.

As stated, there is a wide variety of noise and vibration frequencies to be isolated. It may be shown that if a mounting is designed to isolate a certain frequency, the higher frequencies will be isolated more effectively. For this reason the high frequencies do not present any difficulty unless their amplitudes are greater than those ordinarily encountered.

The foundation upon which a machine is mounted affects to some extent its mounting design. At present, noise problems concern mainly installations in hotels, apartment houses, schools, and office buildings where the foundation is usually a concrete floor. This floor is most sensitive to forces transmitted from the motor in a vertical direction. These tend to bend the floor slab and for this reason the transmitted force normal to the floor should be given particular attention.

Damping is beneficial in the foundation as it reduces the amplitude of the floor vibration which is the source of sound radiation. Since the high frequencies are isolated best by the mounting and are damped most by the foundation, there usually remains as troublesome only the rotational and the fundamental magnetic frequencies.

Elastically-mounted machines may be separated into two classes depending upon whether they (1) transmit torque to apparatus on a separate base or (2) are self contained. Motor-generator sets are of the latter class. Here the stiffness of the support is not limited by the stability of the system against external forces such as belt pull; hence the vertical resonance can be made sufficiently low to isolate the unbalance vibration of the machine, which is the lowest frequency of disturbance present.

RESULTS

A number of motor-generator sets has recently been mounted with marked success on rubber pads. The stiffness of these pads is proportioned to give the set a material frequency in the vertical direction, sufficiently low to insure good isolation. Four pads are usually used, one under each corner of the base.

In the case of polyphase induction motors the magnetic vibration may be in any direction and therefore the stiffness of support for these machines must be low in all directions. On the other hand, the mounting must be sufficiently stiff to withstand belt pull which usually makes it impossible to isolate the low-frequency unbalance vibration. This vibration can be cured at its source, however, by an accurate running balance.

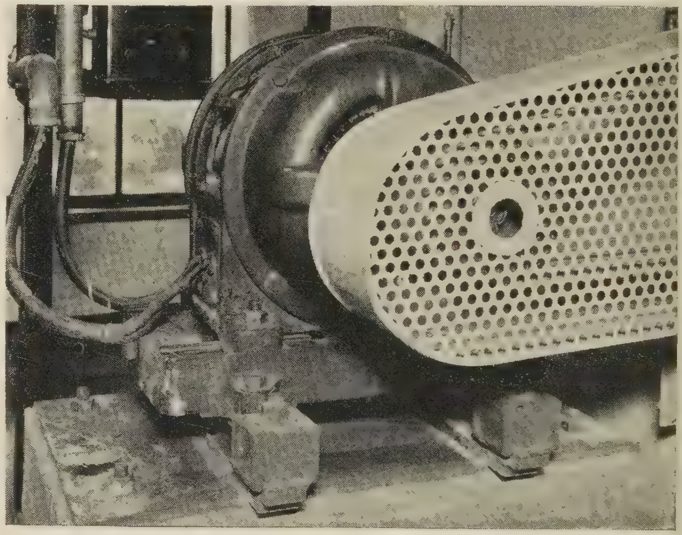

Fig. 3. Induction motor with rubber pad mountings

In Fig. 3 is shown mounted upon rubber pads a variable speed polyphase induction motor used to drive a ventilating fan in a large office building. No noise transmitted from the motor could be detected in the floor. The motor itself was stable throughout the speed range, vibrating through a maximum amplitude of only 0.002 in. at a low frequency due to force transmitted through the belt from the fan. This slight motion however is not objectionable.

This rubber mounting has been compared with all the usual types of elastic mountings by means of a specially prepared sound-box. A motor on the mounting to be tested is placed on top of this box; an observer enters the box and judges the effectiveness of the mounting by the amount of noise transmitted into the box. Results of these tests show that in the prevention of sound transmission the rubber mounting compares very favorably with any of the mountings tested thus far.

The more important results of the investigation may be summarized in the facts that,

1. Elastic supports are useful only when the ratio of the impressed frequency to the natural frequency of the system is greater than 1.41; a ratio of 2 or 3 is sufficient for unbalance vibration, while a ratio of 7 or 8 is necessary for noise isolation.

2. Since it causes increased vibration transmission, damping is undesirable in the elastic member of a support but is beneficial when present in the foundations.

3. If the mounting is designed to isolate low disturbing frequencies, the higher frequencies will take care of themselves.

4. In general, the mounting has six natural frequencies, none of which should occur within ten per cent of the running speed range.

5. For machines which transmit torque, the mounting must be sufficiently rigid in the direction of belt pull to allow stable belt operation.

Measurement of Machinery Noise

By
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MACHINE NOISE INVESTIGATIONS should include vibration tests at various points on the machine and its support, as well as loudness measurements at various points in the surroundings pace. With the "audio noise meter" described in this article, both types of measurements can be made and information thus obtained is extremely valuable in the study of machine noises, their causes and remedies.

For loudness tests, the response of the measuring instrument should correspond with the loudness perceived by the ear. Accordingly a logarithmic scale in which loudness is expressed as the number of decibels[1] (for numbered references see bibliography) above threshold of audibility has been used for the loudness tests involved in this investigation. This choice of threshold or zero loudness as a reference point was made chiefly in order that the results would be comparable with published data on room and street noise.[2]

Reference is here made to a series of contours representing equal loudness which has been set up by Kingsbury.[3] (See Fig. 3 of "A New Meter for Noise Analysis," which appears elsewhere in this series). The contour which at 700 cycles is 30 decibels above threshold of audibility of the average ear has been used as the basis of the response-frequency characteristic of the audio noise meter, for total loudness tests. In the analysis of noise, frequency-weighting by the instrument is not necessary since only one frequency is considered at a time. Thus the loudness of each component is measured separately and referred to the equal loudness contours, a method which gives greatest sensitivity.

DESCRIPTION OF AUDIO NOISE METER

The complete analyzing noise meter is housed in three cases; one contains the measuring amplifier and has space to hold the sound pick-up and tripod; another contains the batteries, while the third contains the analyzer. With this arrangement the meter is portable and may be used with or without the analyzer. Schematic circuit diagrams of all three units are shown in Fig. 1.

The sound pick-up consists of a condenser microphone and a three-stage amplifier enclosed in a separate metal case. Power for the microphone amplifier is obtained from the battery unit.

The amplifier unit consists of a four-stage amplifier with calibrated output meter of the rectifier-milliammeter type, a calibrated attenuator, and an ear-compensation network. Scale and dial are marked in decibels. Tests have shown that over the range of the instrument the readings are closely proportional to loudness.

The analyzer may be connected between the sound pick-up and amplifier to obtain harmonic analysis of noises. This analyzer consists of an electromechanical filter (see Fig. 2) and in order to obtain complete separation of harmonics, it has been designed with high selectivity, yet sufficiently broad at resonance so that small variations of speed or frequency will not seriously affect its operation.

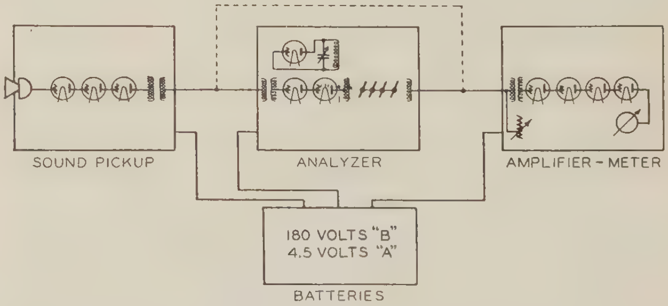

Fig. 1. Schematic diagram of audio noise meter

Complex current to be analyzed is passed through windings on the poles of a driving magnet and a sinusoidal current from a variable-frequency vacuum-tube oscillator is passed through an exciting winding of the same magnet. The resultant flux in the air-gap produces a torque on an armature or vibrator equal in

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From "The Measurement of Machinery Noise," (**No. 31-81**) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

frequency to the difference between the complex wave and the analyzing sine wave, and proportional to the product of their amplitudes. The armature and its supporting stem are designed to have angular vibration resonance at 6,000 cycles. Four vibrators are tuned to the same frequency and coupled in tandem by wires under tension. A permanent magnet with pole windings is mounted in such relation to the fourth vibrator that the motion of the vibrator induces in the windings of the magnet a voltage proportional to its velocity of angular vibration. Mass and compliance of the vibrators and tension of the coupling wires are adjusted so that the combination has characteristics similar to an electrical band-pass filter.

In operation the frequency of the oscillator is varied slowly from 6,000 to 11,000 cycles. Whenever the difference between this and the frequency of a harmonic in the complex wave equals 6,000 cycles, the analyzer responds. The frequency range is therefore 5,000 cycles maximum, the minimum at present being 30 cycles. This heterodyne method of analysis has the important property of equal selectivity for all harmonics.

CALIBRATION

Laboratory calibration is made by comparison with primary sound standards on sine-wave tones of variable loudness and frequency. The instrument contains voltmeters for checking battery conditions but in addition convenient means are provided for an over-all one-point check which can be made in the field.

In the measurement of vibration a device is held against the machine which generates a voltage proportional to its velocity of vibration. This vibration pick-up is substituted for the microphone so that both total vibration and harmonic-analysis measurements are possible. Since the noise is more often proportional to *velocity,* than to *amplitude,* of vibration, this measurement may be used to either supplement or even substitute for sound measurement.

RESULTS

Uses for an audio noise meter are manifold. For some work a total noise test is sufficient, as for example in comparing noise levels in factories or other noisy places, and in the acceptance testing of machinery. If tests are made with the idea of changing design, harmonic analysis is most useful. Fig. 3 shows an analysis of noise from a small synchronous motor in which the noise arises principally from higher harmonics (as high as the 74th) of rotational frequency which is 30 cycles. In synchronous apparatus nearly all noises are multiples of rotational frequency but in induction motors and other variable-speed machines there are usually two series, one based upon power-supply frequency and the other upon rotational frequency.

An analysis of hum from a 325-watt, 60-cycle, 110/1100-volt transformer was made with core clamps loosened, and applied voltage 20 per cent above normal in order to increase the amount and complexity of the resulting noise. Here the harmonics again fell into one series having a fundamental of 120 cycles per second. All harmonics up to the 15th were found to be present in a measurable amount but the fundamental was inaudible. Owing to imagination which would supply a fundamental in order to be logical this would probably not be surmised in a listening test. The effect of loading the transformer was to decrease the total noise, but analysis showed that some harmonics (notably second, sixth, and tenth) were weakened much more than the average.

CONCLUSIONS

Although knowledge of the sense of hearing is still far from complete it is felt that the instrument described serves a very useful purpose in studying machinery noise, the manner of its generation and transmission, and its composition and magnitude.

The analyzer has a high degree of selectivity, is convenient to operate and, combined with sound and vibra-

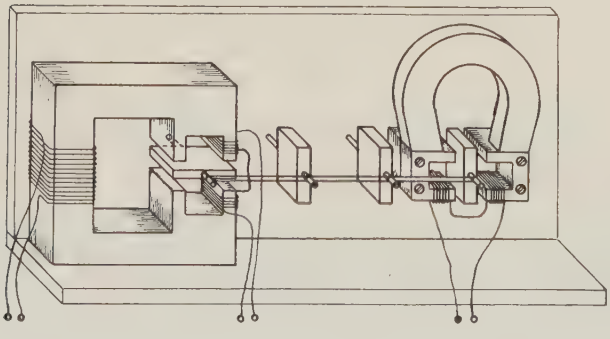

Fig. 2. Electromechanical harmonic analyzer

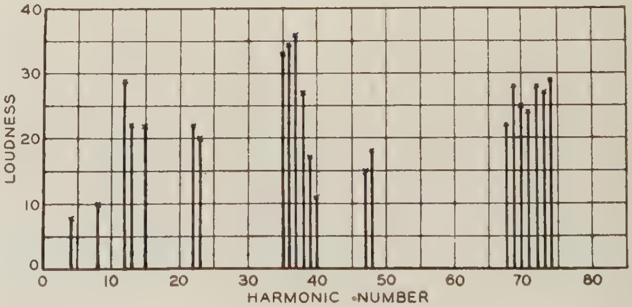

Fig. 3. Analysis of noise from a ¼-hp., three-phase, 60-cycle, 220-volt, 1,800-r.p.m., synchronous motor at no load. The fundamental of the series is rotational frequency or 30 cycles per second

tion pick-up devices, enables quantitative analyses to be made on electrical, mechanical, and acoustical waves.

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Mitigation of Substation Noise

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NOISE REDUCTION IN SUBSTATIONS has in most cases taken the form of confining the noise within certain reasonable limits rather than eliminating it at its source. In accomplishing this, however, other complications are introduced, especially as regards ventilation.

The following classes of substations are discussed in the order named:

1. 230-volt d-c. station located in a downtown district.
2. 600-volt d-c. station for traction service.
3. 1,500-volt d-c. station for electrified railway service.
4. A-c. remote-controlled distribution station.

D-C. Converter Stations

Since the problem of noise due to synchronous converters is common to three of the types of substations mentioned it may be well to discuss it first. Noise emanating from converters is related directly to speed and frequency and in general may be classified as follows:

1. D-c. commutation noise where the brushes riding on the commutator bars and the slots passing under the brushes are contributing factors. High-mica or commutator bars may in addition set up an objectionable chattering noise.
2. Windage, which depends upon the speed of the machine.
3. Magnetic noises which are usually so low-pitched that they are drowned out by other noises.
4. A-c. brush and slip-ring frictional noises.
5. Vibration of the building housing and equipment. This is rather unusual and occurs chiefly if the unit, for any reason, should run on "open phase."

The first measure toward the reduction of converter noise was to provide as a part of the unit a semi-enclosure consisting of a sheet-metal housing with wire glass doors and windows enveloping the d-c. end of the machine. However, when any attempt is made to enclose a converter, a secondary problem of ventilation immediately becomes manifest. In the case of the semi-enclosures this was cared for by leaving an opening in the front end of the housing approximately the same size as the opening inside the commutator. Cool air was then drawn into the armature through the commutator, passed through the ventilating slots of the armature core and windings and discharged through a chimney at the top of the enclosure. In some cases this chimney was connected to a point outside the substation by means of a duct; in others it simply discharged into the converter room. These semi-enclosures effected quite a reduction in noise, but were not satisfactory from either a standpoint of ventilation or accessibility.

The next step was to completely enclose a 600-volt railway converter when the residents in nearby apartment houses objected to its noise. This enclosure consisted of a wall of ½-in. transite supported on a structural steel framework. The inside of this enclosure was lined with 1-in. asbestos hair felt. A baffled chimney on top of the housing permitted the air to be discharged, and deadened a large part of the noise.

From a noise reduction point of view the total enclosure was fairly successful since it eliminated the complaints, but protection against heating was quite a serious problem and required the installation of a blower to force cooling air through the housing. A new problem presented itself when flashovers occurred and small particles of hot copper or carbon were discharged into the hair felt lining. This material did not burn rapidly but due to the draft would smolder, making it necessary to use a fire extinguisher. This was overcome by placing a second lining of ⅛-in. porous asbestos paper inside the hair felt. The net result was satisfactory although the relatively poorer noise absorbing quality of the thin asbestos slightly decreased the over-all noise reduction.

Success in this experiment resulted in the continued development of the total enclosure, which along two general lines is now designed by the two principal manufacturers. The first consists simply of a cubical housing completely enveloping the entire converter, the dimensions being such that the sides are a few inches clear of the machine bedplate at all points. A partition at the main field yoke divides the housing into two sections. Air for ventilation is admitted at the d-c. side of the unit through openings in the foundation, and is discharged through a chimney located in the top on the a-c. side, a blower being required on either the intake or discharge side to circulate the air.

The second design, while completely enveloping the converter, conforms to the general shape of the unit, and is rounded off at the top. The method of ventilation is identical with the first design.

Compared to the semi-enclosures, these total enclosures have the advantages of greater noise reduction,

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better ventilation, and more space available for maintenance and minor repairs. It should be mentioned, however, that complete disassembly is required for major repairs and due to the elaborate ventilation facilities required an added initial cost is involved.

In a recent installation there arose the problem of noise being communicated to adjacent parts of a large building in which was located a theater immediately over the substation. The following measures were taken to provide a quiet installation:

1. The converters of course were completely housed.
2. Converters and transformers were supported on cork insulated foundations.
3. Blowers and motors were likewise mounted on cork foundations.
4. Connections to the air-exhaust ducts were made with a canvas joint.
5. Flexible laminated copper strips were used for the main d-c. terminal connections.
6. To further eliminate the possibility of vibration being communicated along the main copper connections and in turn through the supports to the building steel, several flexible joints were made in these long runs.

The installation has been in service two years and has proved satisfactory in every way.

At the present time, there is under consideration the problem of noise mitigation in 1,500-volt traction substations. The units installed consist of two 750-volt machines with commutators connected in series. They run at a speed of 600 r. p. m. and give rise to an extremely high-pitched penetrating noise. This noise consists principally of two elements; one due to commutators and the other to windage. It is not considered feasible to totally enclose these units because of the hazards which would result from flashovers. A new form of pole tip has been designed, however, to reduce the whistling noise produced by the field poles but as yet no authentic data are available regarding the reduction of noise actually attained.

Before leaving converting equipment it should be stated that from a noise mitigating standpoint, the mercury arc rectifier is the most satisfactory device so far developed. Its operation is silent except for the hum in the associated transformer and the noise of the rotary vacuum pump. The latter device has been much improved since the original installations and is now satisfactory.

A-C. Substations

In a-c. distribution substations, the character of the noise produced is entirely different, consisting chiefly of hum having a fundamental frequency of 120 cycles which is inherent in transformers and induction regulators. The noise in these substations while not nearly as intense as in d-c. stations is nevertheless somewhat above the noise level of residential neighborhoods. In one substation, this noise was found to be transmitted through building steel to the outside walls and thence to an adjoining apartment house. This difficulty was overcome by placing cork under the transformers and regulators, and replacing the rigid terminal connections with flexible ones.

Transformers installed outdoors in remote-controlled substations have been the cause of serious complaints. As a rule, they are installed in an open court adjacent to the building which houses switching equipment and regulators. In a typical case this court consisted of brick walls along the side and one end with a wire mesh screen at the opposite end; the brick walls contained small openings for ventilation. In this case the major part of the noise was confined to the court by placing sound-absorbing felt over the wire-mesh screen and constructing a roof of sheet-metal arc-shaped sections having the under side covered with sound-absorbing felt. These sections were arranged so as to baffle the sound waves and at the same time permit free passage of air.

In summarizing the situation, at least so far as rotating equipment is concerned, very little has been accomplished toward reducing the noise inherent in the machines. Practically all efforts up to the present time have been toward confining the noise to the equipment and in solving the incidental ventilation problems.

Noise from Induction Regulators

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AN IMPORTANT PREREQUISITE to the study of noise in induction regulators is the establishment of a method for making quantitative noise measurements. Surroundings have a very great effect on the values of sound intensity; thus for consistent results all sound measurements should be made under identical conditions as regards not only background noises but also surfaces in the vicinity. Induction regulators, however, are usually difficult to handle and it is therefore quite inconvenient to move them to a place suitable for making sound measurements.

Since surface vibration is the chief cause of noise in induction regulators and since this vibration bears a quantitative relation to the sound produced, many of

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the difficulties experienced in making suitable sound measurements can be obviated by measuring vibration instead. Special surroundings are not required for vibration measurements; with a minimum expenditure of time direct comparison of machines is possible on the test floor during working hours. It is possible also to make representative measurements on the various elements of a machine, tracing vibration to its source and determining the effect of different conditions upon that source.

Noise produced by induction regulators and transformers is quite simple in character as compared with noise produced by rotating machinery. The noise (exclusive of clicking of relays during the period of voltage adjustment) has a fundamental frequency double that of the supply voltage and is radiated directly from the tank walls, cooling tubes, and boxes housing the control panels fastened directly onto the side of the regulator. There may be present harmonics of the fundamental depending on the supply voltage, but usually these are not large.

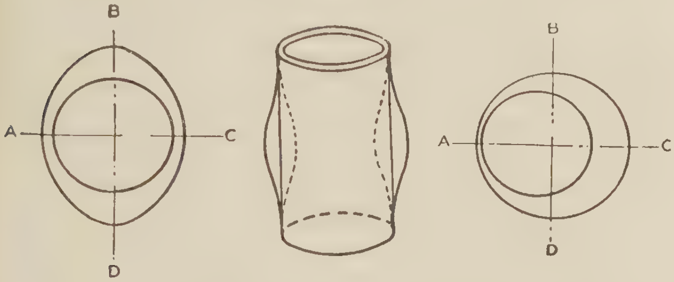

Fig. 1. Illustrating in exaggerated form some factors affecting stator vibration. From left to right, elliptical deformation of the stator by field forces; vibration of stator under radial forces of field; rotor out of center with stator

Experience gained on small single-phase regulators in the past has indicated that invariably noise could be reduced by a well-balanced gap and small clearances in the bearings; however, more recent experience with larger machines has shown that there are several types of vibration (especially in larger regulators) which no degree of accuracy as to mechanical fitting and centering will cure.

According to the source, (See Fig. 1) regulator vibration may be divided under the following three headings:

1. "Hoop vibration" caused by the radial forces set up by the magnetic flux across the air-gap. Since this force is balanced its only effect in the two-pole regulator is to deform the stator into an ellipse with minor axis corresponding to maximum of flux wave. The result of this deformation is a vibration of the stator in a radial direction and is transmitted directly through the oil to the tank.
2. Vibration due to the rotor being out of center or eccentric with regard to the stator. In this case the forces on either side of the rotor are not balanced and there is a resultant force tending to vibrate the rotor and stator as beams supported at the ends. This vibration is transmitted to the tank partly through the top and partly through the oil directly from the stator.
3. Torsional vibration. This is evident in some single-phase regulators, and is carried to the cover through the worm and segment. While this type does not contribute much to the noise directly, if of sufficient magnitude it is liable to cause impact between worm and segment, with a resultant rattle that is quite objectionable.

These types of vibration are all of the same frequency but in any consideration of causes it is necessary to distinguish between them.

The more important type of vibration in large three-phase two-pole regulators is that produced by the elliptical deformation of the stator under the action of the field (hoop vibration). In small machines the stator rigidity is sufficiently high to limit this vibration to a point where the other types of vibration become of importance.

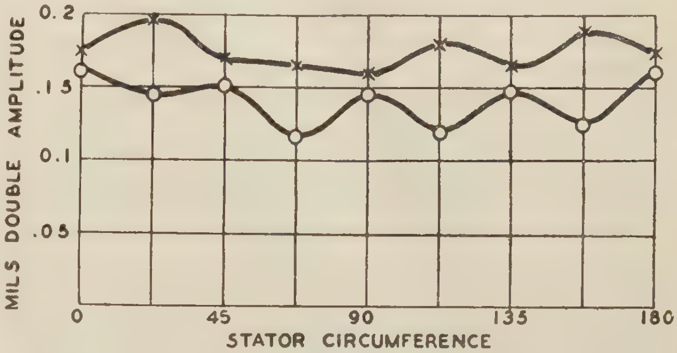

Fig. 2. Relative vibration amplitudes measured on circumference of core (x) and frame (o) of a typical regulator

In designing regulators it is desirable to calculate the probable amount of vibration that will be produced in the finished machine. It is possible to do this approximately by the usual theoretical formula (*Etude Meneanique Et Uswage Des Machines Electriquet,* by H. DePistoye, p. 560) provided certain assumptions and approximations are made.

In the case of hoop vibration the annular rigidity of the stator is the controlling factor so that the amplitude of vibration is the same as the static deflection under the load produced by the force of the field. In a three-phase regulator the field is fairly well distributed but it may be considered as having a sine wave of distribution. For example in a representative three-phase two-pole regulator the double amplitude of vibration was calculated to be 0.14×10^{-3} in. The measured double amplitude on this same regulator (average of several readings) was 0.19×10^{-3} inches.

If the rotor is slightly eccentric in the air-gap the forces of the field on either side of the stator do not balance and the rotor is deflected toward the narrower gap. Vibration having a frequency double that of the supply voltage is set up adding to the hoop vibration on one side and subtracting on the other. The vibration of the rotor is carried to the covers and thence to the outer tank surface. In practise, however, it is quite possible to keep the eccentricity low enough on most large regulators to keep this type of vibration within limits.

Torsional vibrations of the rotor, (due to flexibility in the shaft and worm), are controlled by the mass reaction of the rotor. This type of vibration is not important except in small regulators and large 25-cycle regulators. Torsional vibration does not usually contribute much to the noise directly, but in the worm and segment is a system which has a variable spring constant so that higher frequencies may be introduced due to impact between worm and segment. These lie in the range of greater ear sensitivity and are very objectionable. The introduction of flexibility between rotor and segment or between worm and cover eliminates this difficulty by preventing the vibration from reaching the cover.

While the vibration has its chief origin in the stator core it must pass through the oil before it can affect the tank wall and thus be radiated as sound. The oil is nearly incompressible, however, and thus serves as an excellent medium for transmitting the vibration to the tank. The tank, however, does not follow the core but appears to have on the surface a number of locally resonant regions whose positions are not at all definitely determined. As a result and in order to compare machines, it is necessary to take a number of readings both in a vertical and horizontal plane and obtain an average.

Since cooling tubes are liable to be resonant in themselves their presence further complicates the action of the tank wall. This tube resonance should be guarded against not only on account of noise but because, due to the large amplitudes that occur at resonance, it is likely to fatigue the weld where the tube enters the tank and create an oil leak. In these tubes one may find anything from nearly rigid support to nearly perfect flexibility at end welds. In order to be safe then it is necessary to work outside the region between these two extremes. This resonance region can be computed by consideration of weight of tube full of oil, inertia of cross-section, and length. It is then the problem of the uniformly-loaded beam. Where the tubes are supported one upon another or on the tank at any place other than the end, the problem becomes indeterminate analytically.

With information gained from vibration measurements and some knowledge of the magnetic, electrical, and fundamental mechanical conditions in the general type of structure represented by the induction regulator, it is possible to classify regulator noise according to its source, determine the relative importance of each class in different sizes and types of regulators, and even calculate approximately what to expect from a new design.

Impulse Tests Made on Substations

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Unlike many lightning and surge investigations which have largely concerned individual pieces of apparatus, the tests outlined here have been made on complete substation units. Qualitative results have been obtained for two classes of stations.

During the past few years a great deal of experimental work has been carried on in studying the nature of disturbances due to lightning, and in determining transmission line characteristics, with a view to forecasting the behavior of transients of this nature on transmission systems. To date, experimental work on terminal equipment has been largely confined to the study of individual units; in the summer of 1930, however, the opportunity to study surge behavior on typical substation layouts presented itself. The tests described were made with the aid of cathode ray oscillograph and portable lightning generator equipment of the Westinghouse Company.

An effort was made to check graphically some of the theories generally accepted in regard to the action of a traveling wave striking typical substation structures, in the expectation that the results might serve to clarify general protection problems. It was realized that actual layouts vary greatly, and that test results must depend largely upon the type of station under investigation; also upon the chosen impulse wave. For these reasons, the results secured are largely qualitative in nature.

These tests were made in New Jersey on the system of the Public Service Electric and Gas Company where

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From "Impulse Tests on Substations," (No. 31-44) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

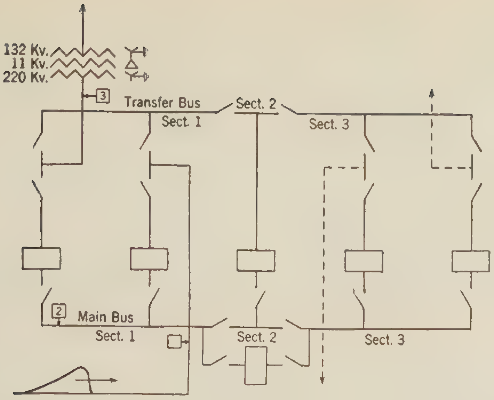


Fig. 1. 220-kv. bus layout at the Roseland substation

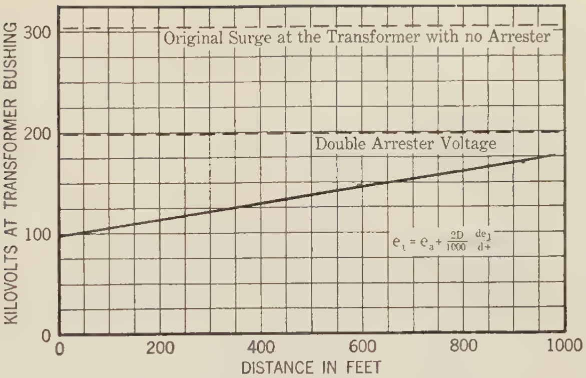


Fig. 2. Variation of impulse voltage at transformer terminals in the Roseland station, as affected by the distance between transformer and arrester

two types of substation structures were made available. The first series of tests was made on the 220-kv. bus and transformers at the Roseland switching station, a typical substation of the high-voltage class; the second, on the structures of the Elizabethport 26.4-kv. distribution substation.

The Roseland station is the terminal point of two 220-kv. interconnections feeding a 132-kv. ring which connects the other switching stations of the system. The 220-kv. structures, while complete, had not yet been placed in service.

A schematic diagram of the 220-kv. bus layout may be seen in Fig. 1. The entire bus, all oil circuit breakers, and one of the transformer banks, were available for connection to one incoming 220-kv. line. To secure a general idea of the distances involved, the conductor length from the terminal of the line to the main bus is about 300 ft. and from the bus to the transformer 330 ft. Main and transfer buses are both 270 ft. in length. The transformer bank consists of three single-phase, 30,000-kva. units connected *Y-Y* with solidly-grounded neutral on both 220- and 132-kv. windings.

Surges were set up by means of the portable lightning generator, located at a distance of eight line-miles from the station. This generator was adjusted to give at the station a traveling wave having a crest of 169 kv., a front of 5.5 microseconds, and a time-to-half value of 19 microseconds. A short surge of 4 microseconds in length with a crest of 140 kw. was obtained by chopping the longer wave by sphere-gaps connected to the line near the surge generator.

It was first desired to determine the modification of wave shape at the station as compared with the wave shape with the line end open. For this purpose volt-time oscillograms were taken at the line terminal and at the transformer with the line connected to (1) the transfer bus alone, (2) section 1 of the main bus, and oil circuit breakers, and (3) to the complete main and transfer buses and all oil circuit breakers. The effect of connecting the transformer to the station network was also investigated.

Table I shows the reduction in crest voltage in per cent of the open-end voltage for each of the foregoing conditions. In general, the crest of the transient is reduced as more and more bus is added to the circuit, and connecting the transformer caused a further decrease. It may be noted that the reduction was somewhat less for the long wave than for the short wave, and it is to be expected that a still smaller reduction would result from longer waves.

TABLE I—REDUCTION IN IMPULSE CREST VOLTAGE FOR DIFFERENT STATION CONNECTIONS

Station conditions	Per cent reduction of crest kv. 19 micro-second wave	 4 micro-second wave
Section 1 transfer bus	4.5	
Transformer connected	11.2	32.0
Section 1 main bus line and transformer breakers	5.6	
Transformer connected	14.0	45.0
Complete main and transfer buses all breakers	24.0	
Transformer connected	35.0	65.0

It was desired also to determine how the distance between the point of location of a lightning arrester and the transformer bushing, would affect the voltage at the transformer. The arresters used for these tests were 25-kv. line-type porous-block units. Oscillograms of transformer voltage were taken for three different locations of the arrester; namely, at the transformer bushing, on the main bus 595 ft. from the transformer, and at the line terminal 920 ft. from the transformer. Results of these tests are shown in Fig. 2. It was found that if only one arrester were connected to a single bus leading directly to a transformer, the voltage at the arrester location will be a minimum; the voltage at any other point will depend upon the arrester's rated voltage, the rate of rise of the traveling wave, and the distance from that point to the arrester. With certain

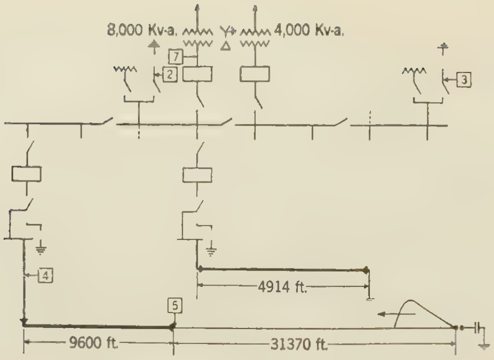


Fig. 3. Layout of bus and lines at the Elizabethport 26.4-kv. distribution station

approximations, the equation of the curve is given by the formula,

$$e_t = e_a + \frac{D}{1000}\ \frac{2\,d\,e_1}{d\,t}$$

where e_t = voltage at the transformer (in kv.)
e_a = arrester's rated voltage (in kv.)
e_1 = crest voltage of traveling wave on the bus (in kv.)
D = distance from arrester to transformer in ft.
$\frac{d\,e_1}{d\,t}$ = kilovolts per microsecond

TESTS AT ELIZABETHPORT SUBSTATION

The Elizabethport substation is designed to receive energy from eight 26.4-kv. cable feeders, and to distribute this energy at 4,150 volts. A schematic diagram of the station layout is shown in Fig. 3. Two of the 26.4-kv. feeders were available for test purposes; also two banks of transformers, the first consisting of two 4,000-kva., three-phase units, and the second a single 4,000-kva. unit. The station bus is about 150 ft. in length.

The line used in the impulse tests extends from the power station for a distance of about six miles in aerial conductor on wood poles to a point 9,600 ft. from the substation, where it enters underground cable leading to the substation bus. In order to secure sufficient distance for establishing a traveling wave effect at the cable pothead, the surge generator was located at the far end of the open-wire line. The cathode ray oscillograph was located at the substation where it could be connected to any point in the outdoor structures.

Connecting bus and transformers to the cable was found to reduce the crest voltage of the waves below the open-end value. A less pronounced modification would be expected here than at Roseland because of the smaller bus capacity and cable impedance. Measurements showed a reduction of only about 5 per cent as compared with the 35 per cent reduction which occurred at the 220-kv. switching station.

In the study of protection to station equipment arresters were placed at three different locations, and the voltage at the transformer measured for each location. Due to limitations on voltage imposed by the insulation of the open-wire line, the maximum test voltage obtainable at the station was about 30 kv. For this reason the arresters used were 6-kv. station type, which had a breakdown voltage sufficiently under the incident crest voltage to secure comparative results.

The arrester locations chosen were (1) the transformer bushing, (2) the main bus 90 ft. distant from the transformer, and (3) the main bus 150 ft. from the transformer. The maximum voltages recorded at the transformer for these positions of the arrester were respectively 21, 23.5, and 25 kv. From these results it is obvious that the problem of properly locating arresters in a station of this size is relatively simple.

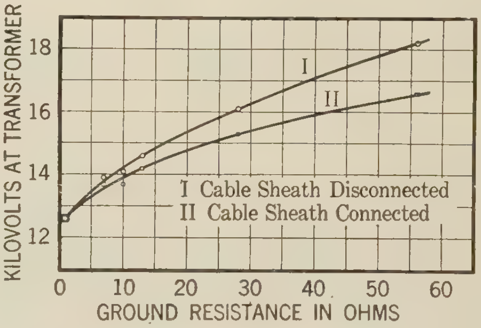


Fig. 4. Impulse voltage at transformer terminals in the Elizabethport station with arrester located on open line at various distances from the cable pothead

Another problem under investigation at this substation was to determine an effective arrester location for a point outside the station, at or beyond the cable pothead. The locations chosen for test were at the pothead itself, and at several points on the open wire at distances of from 300 to 3,300 ft. from this point. Arresters used were of the 6-kv. line type as before. Ground resistances at this location were quite favorable varying in actual value from only about 0.5 to 1.5 ohms.

Results of these tests may be seen in Fig. 4. Due to the decreased conductor surge impedance at the cable pothead, the voltage at this point was insufficient to cause the arrester to breakdown. It may be noted that the impulse voltage at the station decreased as the arrester was moved away from the pothead, the slope of the curve decreasing considerably at about the 1,000-ft. point.

SUMMARY

Summarizing the more important results of both series of tests, it can be said that:

1. The capacity to ground of the bus and circuit breakers in large substations tends to reduce the impulse terminal voltage. In general, the effect of connecting transformers to the bus system is a further sloping off of the wave-front and reduction of the crest. The total effect is more pronounced in the case of very short waves, but appears to be appreciable for those of even moderate length.

2. When lightning arresters are placed on the bus, the voltage at the transformer will be greater than that at the arrester by an amount depending upon the steepness of the lightning transient, the arrester breakdown voltage, and the circuit distance from the arrester to the transformer. Oscillograms show results in agreement with calculations. For any given arrester location the seriousness of such over-voltages decreases with increasing arrester-voltage rating. For minimum impulse voltage, the arrester should be connected to the transformer bushing.

3. Because of the low terminal capacity and low surge impedance of entering feeders in small substations fed by cables, the capacity of the bus and connected apparatus causes only a relatively small decrease in the impulse-terminal voltage.

4. When a lightning arrester is placed on an aerial line joining a long cable leading to a substation, the station protection for a surge originating beyond the arrester is increased as the arrester is moved away from the junction along the open wire. This increase in protection is greatest for the first 1,000 ft. the arrester is moved out from the pothead. The exact arrester location must be selected also with due consideration to the possibility of a lightning stroke between the pothead and the arrester.

5. High ground resistance is found to decrease materially the protective value of line arresters; where this condition exists, arrester performance can be improved by connecting the high-resistance ground directly to the cable sheath. Economic considerations will decide where such a measure should be adopted.

Artificial Sunshine for the Modern Office

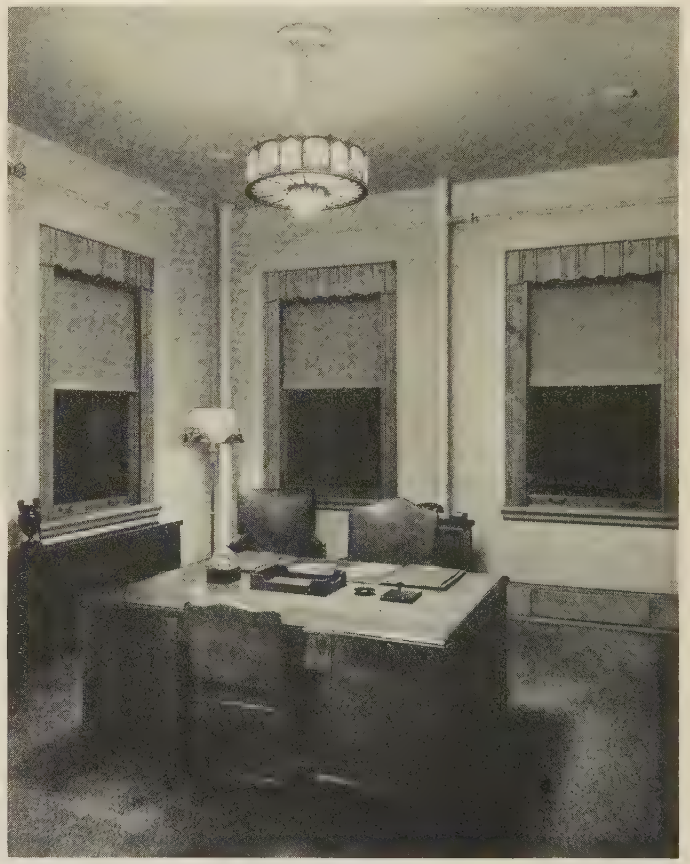
OFFICE SUNSHINE is provided by a special dual-purpose ceiling fixture recently designed for his office by M. Luckiesh, director of the General Electric Company's lighting research laboratory at Nela Park, Cleveland. A similar fixture is installed in the office of the president of the Cleveland Electric League.

These pioneer dual-purpose luminaries supply approximately 80 foot-candles on the desk top without creating a feeling of "too much light." Relatively few offices have artificial light intensities even as high as ten foot-candles and offices with 30 foot-candles are rare. The lighting shown is pleasing and comfortable, and the ultra-violet radiation has the same health-maintaining characteristics as outdoor summer sunshine.

This particular lighting fixture has an upward or indirect lighting component supplied by eight 100-watt incandescent lamps equally spaced in the upper portion connected to two circuits. This alone supplies a general illumination of 10 foot-candles. The downward component of light and the ultra-violet radiation are produced from one "sunlight" lamp (S-1) in the center of an oxidized aluminum reflector equipped with baffle-rings which control the light distribution and ultra-violet radiation and which shield the eyes from direct view of the S-1 lamp.

Like the portable sun lamp, this fixture necessitates the use of a transformer, and in this particular unit it has been conveniently located in the ceiling directly above the canopy.

In buildings where the space between floors will not permit the recessing of a transformer, it is possible to run heavy wires from the fixture to a point convenient for the location of the transformer. This wire should not be smaller than:



Eighty foot-candles of healthful light on the working plane in this office

No. 10 B & S gage for distances up to 15 ft.
No. 8 B & S gage for distances up to 25 ft.
No. 6 B & S gage for distances up to 40 ft.
No. 4 B & S gage for distances up to 60 ft.

Like the studios of the National Broadcasting Company in Chicago where ultra-violet radiation is supplied from overhead units, these office fixtures are creating much interest in the minds of all who have had the opportunity to see them.

Automatic Arc Welding

By the use of arc welding, marked savings have been effected in the manufacture of electrical apparatus. Automatic control for this process has made possible still greater savings and at the same time better and more uniform products.

By G. H. Koch

General Engineer
Westinghouse Electric & Manufacturing Company

ARC-WELDED PRODUCTS and their many advantages over the castings and riveted structures, which they superseded, have been discussed quite thoroughly in various recent publications. The manufacturers of electrical machinery were among the first to take advantage of the flexibility and liberties of new design afforded by the arc-welding process. Automatic control is now being applied to this type of welding and the great saving of time over that required for hand operation is resulting in lower production costs for parts so manufactured.

Where manual welding is employed, the trained welder replaces the trained foundryman or the skilled riveter in obtaining the final results. In both the old and the new processes, then, the quality of the product is as much dependent upon the care and vigilance of the artisan in overalls as upon the judgment and slide rule of the designer. The functions performed by the trained welder were found to be particularly suited to reproduction by machinery. The arc voltage must be maintained at a constant value and the electrode feed towards the arc should be as uniform as is consistent with a constant arc voltage. The progress of the arc along the seam should be steady and at a fixed rate.

In an automatic arc-welding machine an electric motor is used to feed the electrode at the required rate to maintain a constant arc voltage between the electrode and the work. A machine of this type is shown in Fig. 1. As may be noted, the electrode passes through a long nozzle after it leaves the driving rolls and emerges at the lower end to be fused in the arc and deposited on the work. Welding current enters the electrode through the sliding contact in the nozzle.

Elements sensitive to arc voltage automatically regulate the direction and speed of the welding electrode and serve to maintain the arc voltage constant even on an irregular surface. Separate motor-driven devices provide a uniform motion of the arc along the seam and a weaving motion across the seam where this is desired. After the current value, arc voltage, and travel speed are selected for a given job, the operator is required only to start and stop the welding operation, and to change the work. In some high-speed production work even these operations are performed automatically.

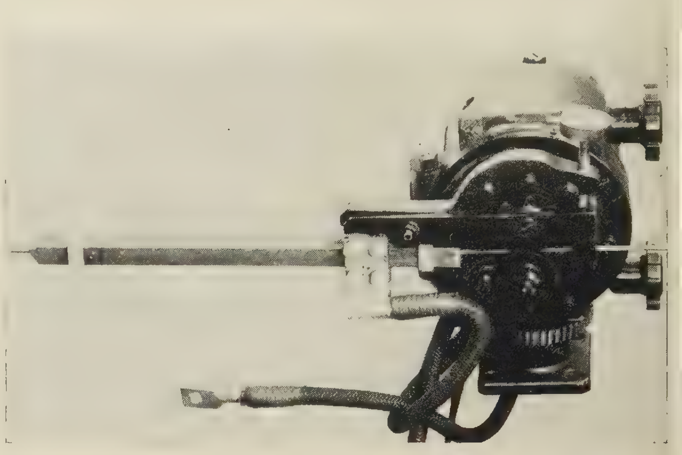


Fig. 1. Automatic welding head showing electrode feed mechanism

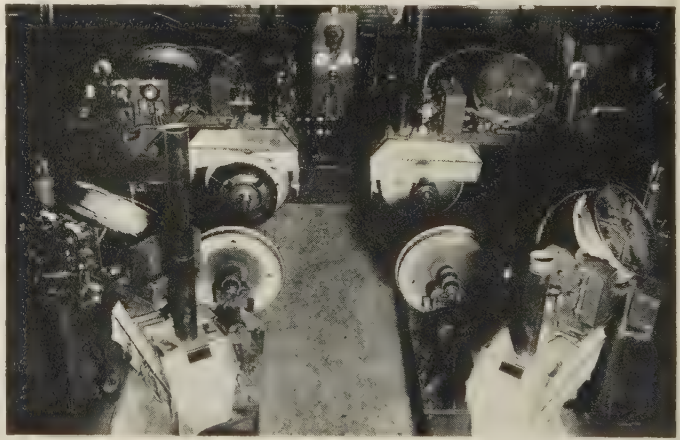


Fig. 2. An installation of four automatic welding heads for building up worn car-wheel flanges

As a general rule on any given job only slightly larger electrodes are used for automatic welding than for hand welding. Increased welding speed is brought about largely by the fact that a higher current density in the electrode is possible in automatic welding than in hand welding. About 25,000 amperes per sq. in. of electrode section is common in automatic welding compared with 10,000 amperes per sq. in. in hand welding. This increased current concentration provides for better fusion and improved arc stability. Usually less deposited metal is required in automatic welding because

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From a paper presented informally at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

of this factor and because of the greater general reliability. Furthermore, since the electrode is fed continuously from a reel, there are no interruptions such as the manual welder introduces in changing electrode rods. All of these factors tend towards increased speed and better welds.

The comparative welding speeds for automatic and manual arc welding are now fairly well known for existing commercial electrodes. In general it may be said that simple, continuous welds may be made with an automatic welding head in from one-third to one-sixth of the time required by an expert manual welder, depending upon the thickness of material.

One of the earliest applications of automatic welding in the electrical industry was in connection with the repair of worn flanges on steel street-car wheels. Unless the worn section is built up by welding, an excessive amount of material must be cut from the face of the wheel to restore the proper face contour. An installation of four automatic-welding heads in a large street railway repair shop is shown in Fig. 2. One man can keep the four automatic arcs in operation, thereby doing the work of twelve manual welders. The automatic weld sets up much lower shrinkage stresses in the wheel than a manual operation since a large number of beads are added successively at a relatively high speed thereby providing uniform heat distribution.

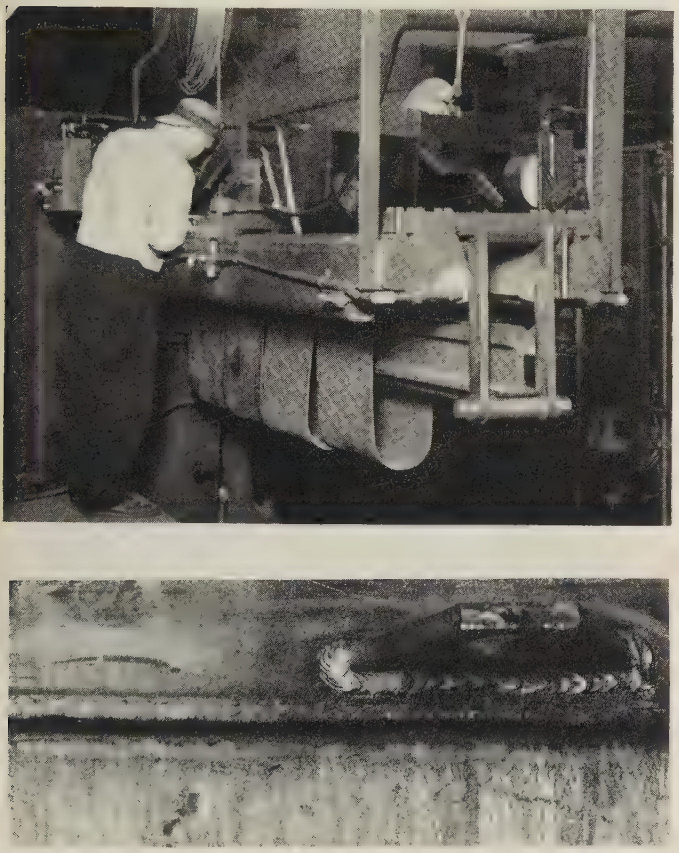

Fig. 3. Special clamp (above) for holding tank sheets and tubes during welding process. Note thickness of material in finished weld, (below)

Automatic welding next was introduced into the manufacture of sheet-steel tanks for transformers and circuit breakers. A seam-welding clamp used to make longitudinal butt and lap welds in round, elliptical, or rectangular tank shells is shown in Fig. 3. A large shell or a number of small ones is held against a backing bar by air-pressure clamping fingers and the weld is made by the automatic head which is mounted on the traveling carriage. Mounted also on this carriage are the electrode reel and operator's controls. The carriage is self-propelled at any desired welding speed on a trackway built integral with the air clamp frame.

With this apparatus an oil-tight, reenforced butt weld can be made on 5/16-in. steel at a rate of 20 ft. per hr. without beveling or otherwise preparing the edges. This type of weld is reenforced on both sides; it also must pass rigid inspections for appearance as well as for strength and density, and for these reasons is often made in two or more passes. Such a weld can not be duplicated by an expert manual welder at a speed greater than 6 ft. per hr., using commercial electrodes. It is thus evident that the use of the automatic welder in this case results in a time saving of about 70 per cent. On lighter plates this saving would be still greater.

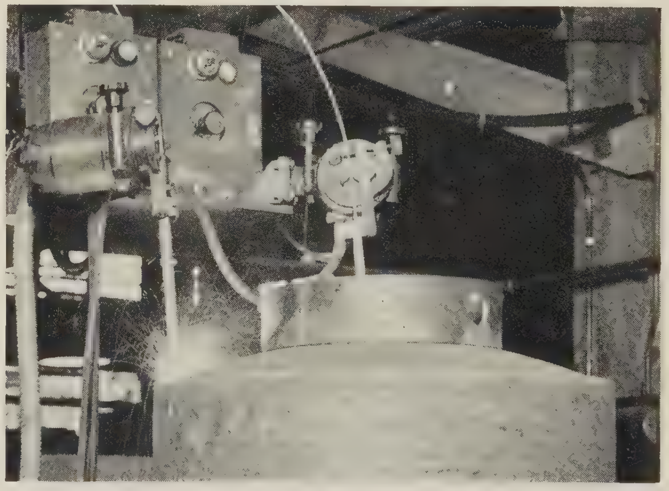

Fig. 4. Welding end plates in a circuit-breaker tank showing two automatic heads in operation.

A method for welding bottoms in cylindrical circuit-breaker tanks is illustrated in Fig. 4. The shell is centered on a turntable flush with the floor level and is rotated under the arcs held by two automatic heads. In this way the bottom of a 42-in. diameter tank with a $\frac{3}{8}$-in. wall thickness is welded in 18 min. by a single operator as compared with the $2\frac{1}{2}$ hr. required by a manual welder to complete the job.

With the recent advent of electrical machinery frames fabricated from structural members and plates welded together, automatic welding received another impetus. A machine especially developed to weld short, straight seams such as would be encountered in this type of work is shown in Fig. 5. In this device the welding head is mounted on an arm which reciprocates along the joint at welding speed. The wire reel and operator's control are mounted on the base of the machine so that the entire unit may be moved to a heavy piece of work within the radius of the supply cable reach.

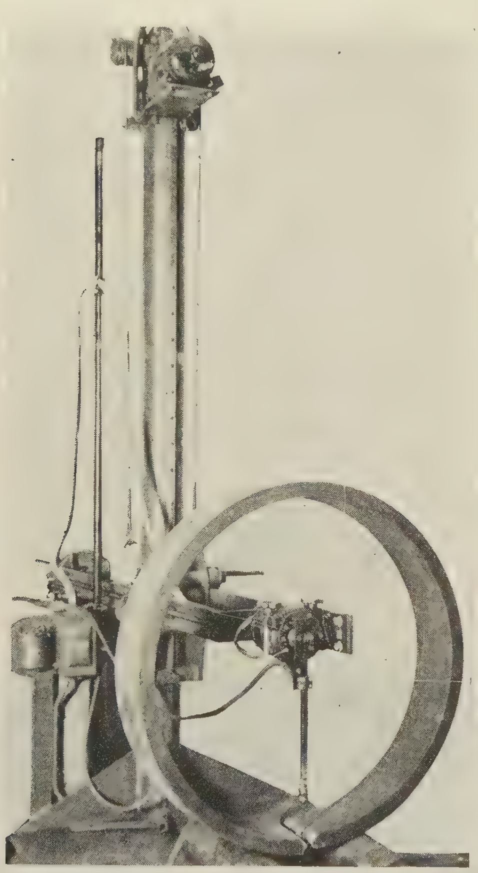

Fig. 5. Machine for making short, straight welds. A structural-steel motor frame may be seen, set up for processing

For heavy fillet welding it is necessary to tilt the work to obtain the most satisfactory results. This is especially true of plates greater than 5/16 in. in thickness for a full-strength fillet. A machine designed to accomplish this purpose is shown in Fig. 6. Tilting the work in this way permits maximum welding current and metal deposits and results in a normal fillet similar to that produced by an expert hand welder with proper manipulation.

Automatic welding is not by any means limited to heavy welds or large joints. As a matter of fact, the time saving over manual welding is much greater on thin sheets and small beads. With a special machine designed for this service certain welding operations now are performed in 45 sec. which required 7 min. for manual welding. In this case, the welding speed was 140 ft. per hr. However, a speed of 200 ft. per hr. could easily be obtained with increased welding current, but would result in a slight sacrifice in appearance.

Another interesting application of automatic welding is in connection with the manufacture of textile motors. The service requirements of these motors demand extraordinary strength and sturdiness for protection against vibration and uneven torque load. As may be seen in Fig. 7, the stator punchings and end-rings for the bracket fits are made integral by welding four angle plates across from one end-ring to the other with a fillet weld at each plate edge. These eight welds are made while the parts are held together in a jig after removal from the assembly press. As a result both the punchings and end-rings are individually welded

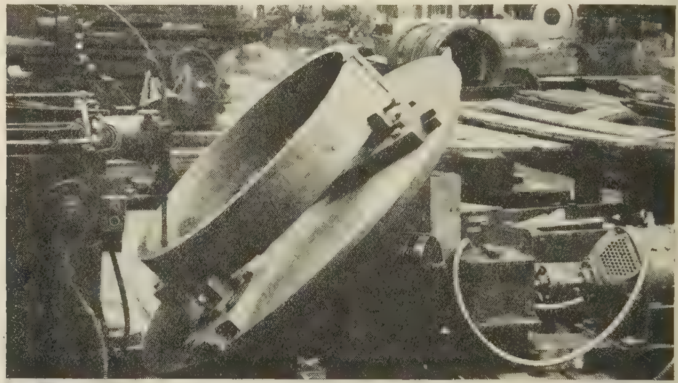

Fig. 6. Machine used in tilting heavy pieces for fillet welding

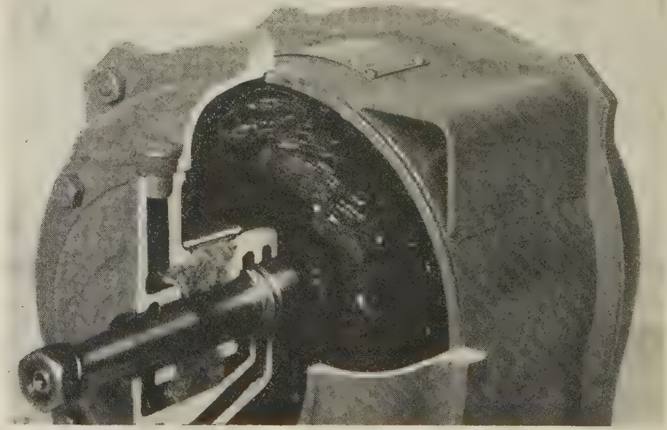

Fig. 7. Section of textile motor assembled by automatic welding. Note that laminations and end rings are held together by fillet-welded angle plates

to the angle plates and are held together under assembly pressure.

The saving in welding time affected in each of the applications illustrated give a good indication of the possibilities of the automatic-welding head in leading the way to new production economies. Provided apparatus is included to limit the handling time in changing the work, and provided such apparatus can be installed at reasonable expense, nearly every production welding job from an economical point of view, is open to automatic welding. In some applications, handling time is unavoidably the bulk of the welding time; in such cases, automatic welding can still be considered advantageous on account of its improved and consistent results.

Percentage-Differential Transformer Protection

Three-winding transformers present difficult problems for the protection engineer. Differential relays which operate on the phase difference between the currents in the different windings are particularly adapted to meet the requirements.

By R. E. Cordray

General Electric Company
Philadelphia

PROTECTION of three-winding transformers became a problem for serious consideration shortly after the introduction of this type of transformer a few years ago. The special requirements of these transformers necessitated that any suitable scheme of protection in case of an internal fault must remove the transformer from all three of its associated circuits simultaneously. In addition, an external fault on any one of its associate circuits must be cleared without putting the transformer out of service. Differential relays which operate on the phase difference between the currents in the different windings are particularly adapted to meet these requirements.

Occurrence of an internal fault in a three-winding power transformer requires the complete isolation of the transformer in the shortest possible time. In addition to this requirement, the protection must carefully discriminate between internal and external faults such as those occurring on associated transmission lines. It would be desirable of course to have the protection sufficiently sensitive so that it would function on the least possible fault; as for example, one between adjacent turns. Among other factors which affect the sensitivity are possible false operation and economy of winding replacement. However, assuming that the protective relays would operate instantaneously even a turn-to-turn fault would probably damage several turns or even a whole section of the winding before the circuit breakers could open.

Probability of a ground fault inside a transformer—that is, a fault between the winding and the core—is becoming more remote as the design of transformers continues to improve. A feature of one modern design for medium and high voltages is the complete covering of the iron core with a cylinder of very heavy insulating material, and the separation of the different voltage windings by similar insulation. For the same reason faults between phases are also becoming scarcer. Consequently, the problem consists principally of protecting against faults between turns or parts of the same winding.

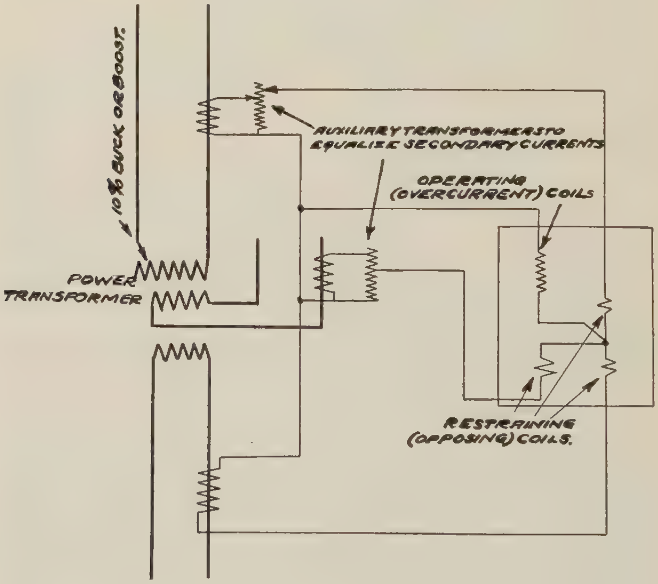
10% BUCK OR BOOST.
POWER TRANSFORMER
AUXILIARY TRANSFORMERS TO EQUALIZE SECONDARY CURRENTS
OPERATING (OVERCURRENT) COILS
RESTRAINING (OPPOSING) COILS.

Fig. 1. Schematic single-phase diagram for percentage differential relay

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From a paper informally presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

PERCENTAGE DIFFERENTIAL PROTECTION

Differential protection of three-winding power transformers, as mentioned in the beginning, operates on the vector difference of the currents flowing in and out of the transformer. This protection is theoretically free from the effect of external faults, because, neglecting the exciting current, the vector difference between these currents is zero except at the time of an internal fault.

Practical application of this theory has been accomplished by connecting in parallel the secondary windings of all the current transformers in each phase, providing their ratios are such as to exactly compensate for the different voltage ratios of the power-transformer windings. In practise, such differences as do exist are easily compensated for by using auxiliary autotransformers in the current-transformer secondary circuits.

Unfortunately current transformers do not in general maintain the same ratio characteristics up to many times their full-load rating. This performance characteristic is aggravated by the current transformers being generally of different types, with one set frequently of the bushing type. This difficulty is overcome by using the percentage differential principle.

Percentage differential characteristics are in effect an automatic means of raising the setting of the relay at the time of a through fault. This automatic raising is obtained by having elements in the relay energized by the through currents; that is, by the current in each of the power-transformer windings. These elements act to oppose the torque of the operating element actuated by the "difference" current. By proportioning the number of turns in these windings it is possible to secure relay operating characteristics having any percentage desired.

Connections required for a typical relay installation of this type are shown in schematic form in Fig. 1. The relay shown here provides a separate restraining torque from each of the three power-transformer windings. Current values for torques so proportioned that the operating-coil current is 25 per cent of the average restraining or through current are shown in Fig. 2. In actual practise this proportion is set sometimes as high as 50 per cent.

A great advantage of this percentage characteristic is that it can be used on power transformers with voltage taps, even where taps are automatically adjusted to meet load conditions. In Fig. 2 is shown the "difference" current which exists when the bank has 10 per cent buck or boost taps in addition to the 25 per cent differential relay characterics. The protection afforded the power transformer is practically the same regardless of whether taps are at the zero, maximum buck, or maximum boost position.

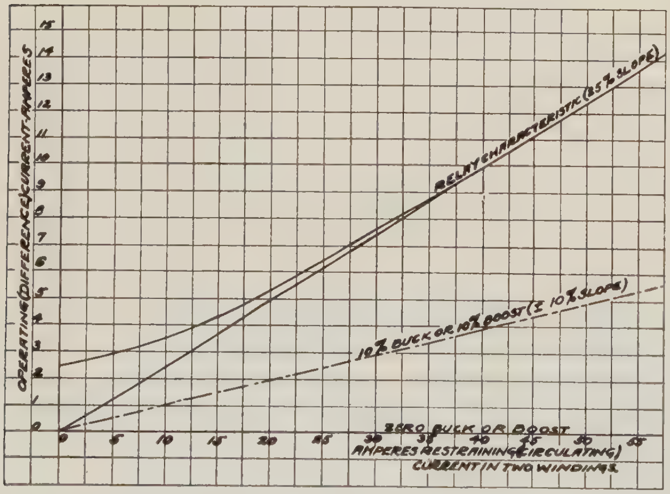

Fig. 2. Relay characteristics for 25 per cent differential protection

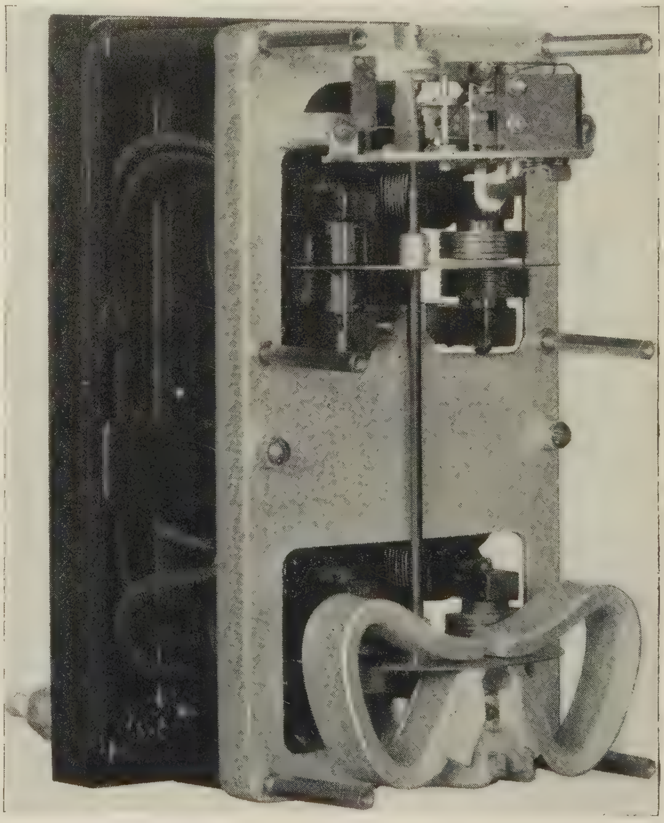

Fig. 3. Front view of differential relay with cover removed

EFFECT OF MAGNETIZING CURRENT INRUSH

Control springs for adjusting the minimum operating current are provided on these relays and are similar to those found on induction-type overcurrent relays. Minimum-current settings are determined by the probable inrush of magnetizing current to the transformer. In general, the magnetizing current is of the order of only 5 per cent of full-load current; but at the instant of energization, an inrush of transient magnetizing current generally results.

Calculations and actual tests show that the peak of this inrush of magnetizing current can be as much as eight to eleven times the full-load current rating of the power transformer (about 200 times the normal exciting current) and that this current may remain *greater* than full-load value for a relatively long time—30 to 60 cycles on a 60-cycle system.

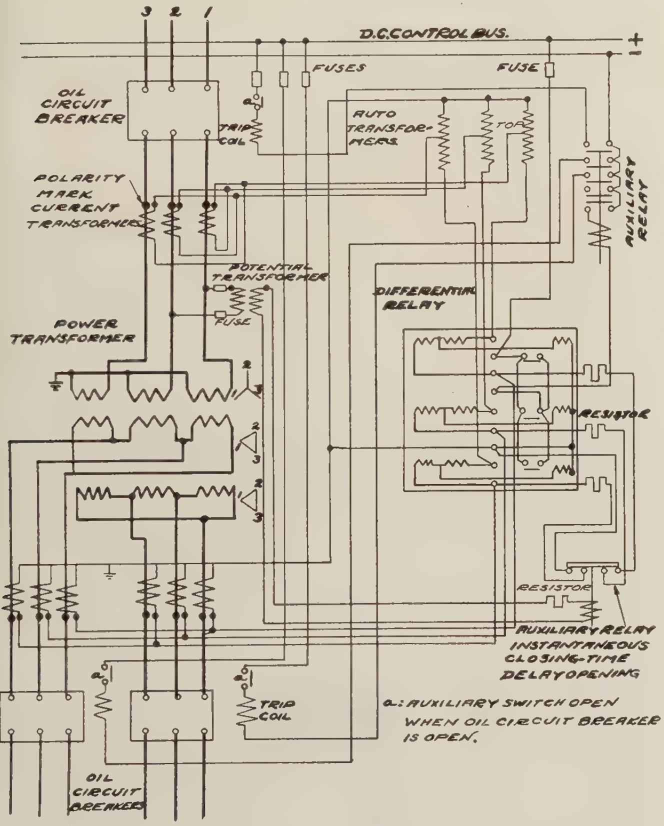

Fig. 4. Complete wiring diagram for percentage differential protection; note potential transformer and auxiliary relay for raising main relay setting during magnetizing current inrush

Relatively high current settings therefore are required to prevent relay operation during these magnetizing transients. One plan of solving this difficulty consists of using an additional relay to momentarily raise the differential-relay setting to a higher value when the power transformer bank is first energized. This relay is operated from a potential transformer placed across any one of the power-transformer windings inside the oil circuit breaker connections. While the power transformer bank is de-energized, the voltage-relay contacts connect a resistor in parallel with the operating coils of the differential relay, thereby raising their current setting. When the transformer is energized the voltage relay operates after a predetermined time delay, thereby disconnecting the parallel resistor from the differential relay after the cessation of the magnetizing-current transient.

A complete wiring diagram for a typical percentage differential relay installation is shown in Fig. 4. This diagram shows also the connections for the voltage relay just described.

Automatic Speed Regulation

Automatic regulators to be suitable for industrial use must be quick in response, sturdy in construction, require a minimum of maintenance, and be adaptable to a wide variety of applications. How one of the newer types of carbon-pile regulators meets these exacting requirements is outlined in some detail.

By J. H. Ashbaugh

Associate A. I. E. E.

Westinghouse Elec. & Mfg. Co.
East Pittsburgh

ACCURATE speed control constitutes one of the biggest problems confronting the regulator engineer and one of the most important phases of regulation in industry. It is important because every progressive industry is striving to improve its products and to reduce manufacturing costs.

The increasing use of individual motor drives has done much to improve quality, increase production, and reduce costs. However, this same trend has made regulation a more important problem because in many processes the individual motors must be closely and accurately controlled.

Certain applications, such as galvanizing machines, continuous rod and strip mills, and sectional paper-machine drives, require practical synchronization of several motors, and at the same time necessitate a wide speed range. These conditions demand the use of d-c. motors which generally operate from a variable-voltage supply with individual regulation for maintaining a

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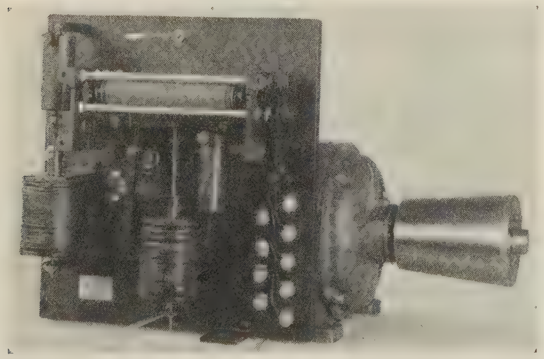
From "Automatic Regulators in Industries," (**No. 31-36**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

synchronized, but adjustable, relation between motors. Speed regulation of d-c. motors to make their characteristics simulate those of synchronous machines, even under highly fluctuating load conditions, now is an accomplished fact.

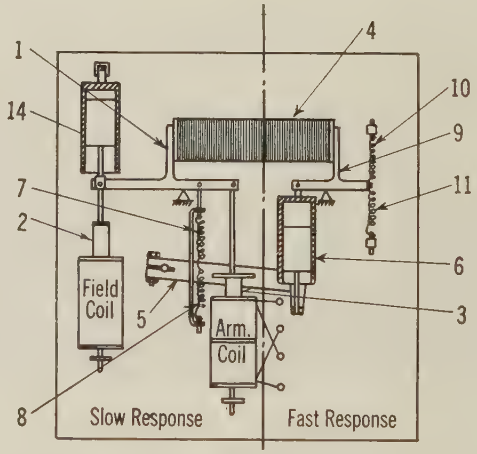
Carbon-pile regulators for this service are extremely simple and exceedingly sturdy. They are capable of field forcing or over-regulation, have effective anti-hunting characteristics, and use no contacts in the controlled circuit.

One of the newer types of carbon-pile regulators is shown in the accompanying illustrations, and may be seen to consist essentially of an electrical unit and a mechanical unit. The mechanical unit is merely a differential, consisting of a worm and nut, a clutch, and a lever system. The unit is made integral with a small synchronous motor which has a hollow shaft through which passes an internal shaft, one end of which drives the differential nut through the friction clutch, the other end being attached to a cone pulley. With the regulator motor driving the worm and the regulated motor driving the cone through a belt, any angular displacement occurring between the two is transmitted directly to the electrical unit which acts immediately to correct the undesired change in the regulated motor.

Characteristics of the electrical unit are such that should the aforementioned angular displacement occur rapidly, the electrical element will respond quickly; but if the change is slow, the correction will be correspondingly slow. As may be seen from the accompanying sketch, the pressure applied to the carbon-pile is varied by the differential lever (5) through the dash-pot (6) and two springs (7-8). The carbon-pile, of course, is connected in the field circuit of the motor to be regulated; two coils are connected to lever (1); coil (2) is in series with the field of the motor, and coil (3) is energized from the interpole. These coils stabilize the regulator and prevent hunting.



Front view of carbon-pile speed regulator for a d-c. motor



Schematic diagram of carbon-pile regulator showing mechanical parts

When a large angular displacement occurs lever (5) moves rapidly, transmitting power momentarily through dash-pot (6) to vary the pressure on the carbon-pile (4). The two springs (10-11) gradually return the dash-pot and lever to a neutral position. The sudden change in field and armature strength causes coils (2-3) to move in such a direction as to anticipate the return to normal conditions; they exert a force on the other end of the pile by deflecting springs (7-8). Dash-pot (14) merely stabilizes the lever and coil inertia. When a slow, angular deflection takes place dash-pot (6) is not moved because the air in it seeps out through an adjustable vent hole. Lever (1) is deflected by varying springs (7-8), resulting in suitable change in pressure on the carbon pile.

This regulator gives a d-c. motor the same characteristics as a synchronous motor. In actual service on a 150-hp. 900-r. p. m. motor the device completely restored and stabilized the speed within three seconds after the instantaneous application of 100 per cent load on the motor.

Considering the broader aspects of the subject, regulators may be divided into three classes; mechanical, hydraulic, and electrical. The progress of development has been in the order named, but because of the flexibility of electrical regulators they soon greatly predominated. In order to prevent surging of the quantity regulated an electrical regulator of course must have incorporated in it the same fundamentals (although in a different form) as the mechanical or hydraulic regulators. This involves careful consideration of the inertia of the system to be regulated and the precision of regulation desired.

In addition to industrial speed regulation, it is possible to effect the close automatic regulation of voltage, load, power factor, pressure, temperature, and many other quantities of importance to the modern industrial concern.

The future of regulators appears to depend largely upon the electron tube. This device is in its infancy but is thought to offer great possibilities in the elimination of moving parts and through its greater sensitivity.

Interchange of Industrial Power for Better Operating Efficiency

Large industrial establishments usually are interconnected with electric utility systems for the purchase of power; but free interchange of electric power between the two is not nearly so common as the economies involved would substantiate. The author recommends unrestricted interchange for the best economy in both systems.

By
*W. B. Skinkle**

Engineer, Pittsburgh District Power Committee,
Subsidiary Companies U. S. Steel Corporation

FREE INTERCHANGE of electric power between large industrial establishments and electric utility systems offers attractive economies to both parties in spite of inhibitions to the contrary. Interconnections are common, of course, between industrials and utilities, but usually the contracts covering such interconnections are narrow and rigid rather than flexible, and usually provide definitely for (1) the utility to furnish all the power; (2) the utility to furnish a certain stipulated base load; or (3) the utility to furnish stipulated peak power and emergency energy. However, numerous engineering analyses and an increasing amount of practical operating experience show that the greatest economies to both parties are realized through unrestricted interchange of power wherever the industrial has large quantities of either by-product or very low-priced fuel available in a form that is not economical to store.

The possibilities of power interchange between utilities and industrials open up a vast field of industrial economics; however, because of an almost unlimited number of special conditions which surround and limit each point of connection, and because industrial conditions are subject to radical and almost momentary change, too often these opportunities for power interchange are given up as impossible because of their involvement. True, such changing conditions do introduce a handicap to the drafting of sufficiently flexible contract agreements, but if both contracting parties will recognize the critical and essential fact that both parties must benefit financially from an interchange agreement, many common difficulties practically dissolve themselves. An interchange agreement should be sufficiently flexible to permit the industrial to draw power from the utility as required and deliver power to the utility whenever a surplus of low-priced fuel is available.

It naturally follows, of course, that the prices for the various kinds of power interchange should be fixed at a rate that will permit any of the classifications of power to be profitably sold by one party, and profitably purchased and absorbed by the system of the other party. Analyses of the interchange problem show that five different classifications of power may be involved in any interchange agreement between a utility and an industrial:

1. Firm power sold by the utility at any time and in any quantity up to the limit of either the contract or the equipment.
2. Surplus power available from either system by reason of surplus generating capacity, idle and awaiting growth of the system on which it is installed.
3. Off-peak dump power.
4. On-peak dump power. Dump power of either classification is power available in the industrial system by reason of surplus by-product heat or fuel which does not lend itself to practical or economical storage.
5. Lastly and most important, the emergency power available from either system to the other on short notice in case of sudden and unforseen operating emergencies.

All of these different classes of power have radically different costs to the producer and radically different values to the purchaser. A mutually acceptable determination of these factors is not extremely difficult to arrive at, and certainly forms a sound basis on which to write a mutually profitable interchange contract.

From the standpoint of the industrial establishment having available an appreciable quantity of heat energy or by-product fuel which is lost unless converted into electric energy and dumped onto the utility system, the conversion of this into electric power is accepted as the logical step. This presupposes the installation of generating equipment capable of absorbing the by-product energy and capable also of carrying some portion of the plant load. In the course of normal operation it is but natural that plant electric power requirements and plant production of by-product heat or fuel may be anything but well synchronized, with the result that at one time there will be more plant-generated power available than can be used, while at another time the power demand will exceed the plant generating capacity. Operating records are available to bear witness to the fact that these irregularities between power production and power demand can economically be smoothed out by interchange interconnection with an operating electrical utility. On the basis that boilers and turbines are already in operation and that their fixed costs and heat losses are already being absorbed by the industrial, the additional cost to the industrial for an increment of load added to the already existing plant load will be in the neighborhood of 0.4 mill per kw.-hr. for the average modern 15,000-kw. turbine-generator unit.

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*Specially written for ELECTRICAL ENGINEERING; based upon and prepared from a discussion presented by the author at the joint A. I. E. E.-A. I. & S. E. E., meeting at Pittsburgh, March 13, 1931. Published by special permission of the Association of Iron & Steel Electrical Engineers, Empire Building, Pittsburgh. All rights reserved.

To the electric utility an interconnection with a large industrial establishment is attractive because of the possibilities in load development. Extending a mere interconnection into a full interchange may have features equally attractive to the utility and to the industrial. The utility, like the industrial, is faced with the necessity of having available more generating capacity than required to meet average load conditions, and thus may have available "surplus" power of its own. However, in view of its different basis of operation including the fact that it must use new fuel for each increment of power output, its actual cost per kw-hr. (delivered at the point of interconnection with the utility) is necessarily higher than the cost of the above mentioned industrial dump power. This is particularly true when transmission, distribution, and apparatus losses are taken into consideration. These features combine often to make it possible for the utility to purchase advantageously dump power from the industrial, even to the extent of reducing the output on its own existing equipment.

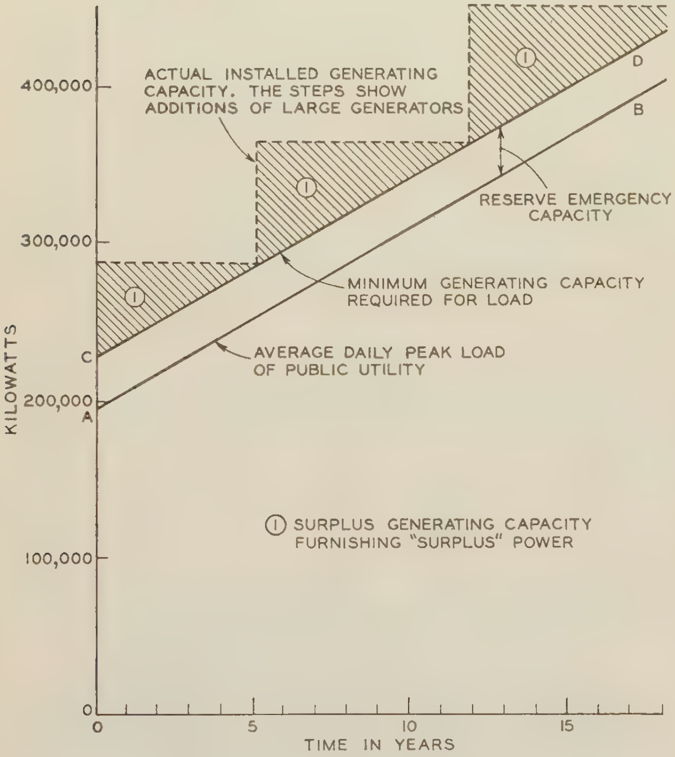


Fig. 1. Diagram indicating common method of caring for load growth in a utility system which must depend solely upon its own plants for increased generating capacity

Another economic angle to the situation, attractive and of importance to both the utility and the industrial, is that through the free interchange of power between the two systems the additions of generating capacity to each system may be "staggered," each making mutually advantageous use of the combined generating capacities of the two systems. This is perhaps one of the most important features involved in the whole interconnection interchange problem and perhaps may be better explained by centering the discussion around the two accompanying illustrations. These illustrations also will help to demonstrate the relative values of the different classes of power previously mentioned as being involved in an interchange interconnection between an industrial establishment and a utility system.

In Fig. 1 the line *A B* represents the constantly-increasing daily peak-load average during the normal growth of a public utility system. When such a system has no major power interchange interconnection, and must care for its own growth with increases in its own generating capacity, a normal margin of safety such as that represented by the vertical distance between the line *A B* and the line *C D* must be maintained. Thus the line *C D* represents the constantly increasing minimum of generating capacity that must be maintained for system operating safety. In the interests of operating efficiency and investment economy, increments in generating capacity must be made in relatively large units, such as those indicated by the projection above the line *C D*.

The capacity shown by the vertical distance between the line *C D* and the dotted lines representing the upper margin of the added capacity blocks represents "surplus generating capacity" held idle and in reserve waiting for system growth. The investment in this surplus capacity must be made *in advance* of the requirements of the system for *any part of its output*, and the fixed charges on this investment must be absorbed by the system as a whole.

When two systems make an interconnection for the purpose of interchanging energy and sharing the beneficial results of such an interchange, the combined operations can best be explained by the aid of Fig. 2, in which the upper section represents the operations of the electric utility and the lower section the operations of the interconnected industrial establishment. The sloping line *C D* represents the minimum safe generating capacity as in Fig. 1. Superimposed on line *C D* are the blocks enclosed by dotted lines representing the normal additions in generating capacity that were shown in Fig. 1. The sloping line *E F* in the lower section represents the same values for the industrial establishment. An hypothetical set of additions to generating capacity on the industrial system are shown in the steps on sloping line *E F*.

A typical normal set of operating conditions that might obtain at the beginning of operation of an interchange agreement may well be assumed to be as shown in Fig. 2. Both companies have power from surplus generating capacity available for sale. Because the electric-utility system does not *need* additional energy the industrial takes advantage of contract clauses permitting the sale of low-priced dump energy, and delivers that kind of energy to the utility system. With the growth of the industrial load its surplus generating capacity gradually is used up and at point 2 the industrial load has grown to a value that requires additional generating capacity; however because of the relatively small capacity required it is more economical to arrange for power purchase from the utility, and by so doing delay an investment in additional generating capacity until a definite load for the reserve unit has been developed.

Because of "minimum clauses" probable in such a power interchange contract, an actual purchase up to the amount of the specified minimum takes place and the industrial buys a small block of power thereby shutting down its most inefficient unit. At point 3 the utility reserve has decreased, as a result of its own load growth, to a point which requires that the industrial again pick up its load. Because of the economy of large units the industrial installs more capacity than is immediately required, and again takes advantage of the low-priced dump-energy clauses to deliver power to the utility system earning at least the fixed charges on its investment in surplus generating capacity, which otherwise would be idle and non-productive between points three and four. At point four the utility has used up its own reserve and is in the market for the purchase of surplus capacity which in this case can now be furnished by the industrial establishment until such time as point five is reached. At that time the utility must have additional generating capacity available for operation, and the first cycle has been completed. These cycles may be repeated indefinitely, the actual span of years per cycle depending upon conditions prevailing.

Fig. 2 indicates that during periods 1-2, 3-4, 5-6, 7-9, and beyond 10, the industrial profits by the sale of dump power and the utility profits by the purchase of that very cheap power. Some power is supplied to the electric utility by the industrial from its own surplus generating capacity during the periods from 4 to 5 and from 9 to 10. During periods 2-3 and 6-7, the industrial has purchased base-load power from the utility. The utility has sold some power from equipment that otherwise would have been idle, and thus has helped to carry the fixed charges on the otherwise idle equipment, and also has been able to delay the large investment in new generating capacity for the periods of time represented by the time increment between point 4 and point 5, and between points 8 and 10. A parallel situation has been comparably remunerative to the industrial establishment. A utility investment in additional generating capacity may easily reach $6,000,000, which if delayed for even one year means a saving of some $780,000 in fixed charges. Large industrial establishments may spend as much as $2,000,000 on power plant equipment; hence the fixed charges on that investment will amount to $260,000 per year, and that investment probably can be delayed for a relatively longer time than the corresponding utility investment. These savings represent some of the fruits of power interchange between the two systems.

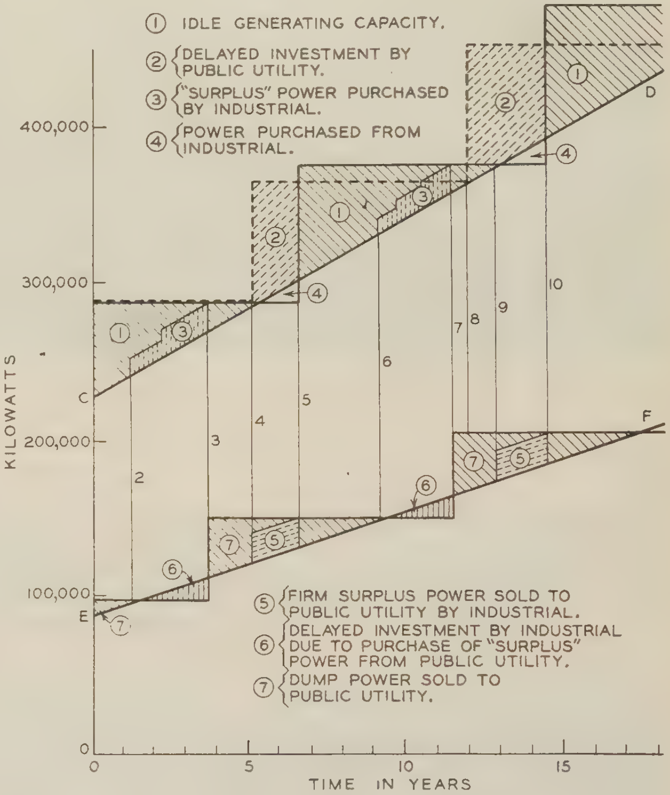


Fig. 2. Diagram showing interlocking development of interconnected utility and industrial systems where mutual use is made of total generating capacity of combined systems

In this brief sketch the attempt has been to outline some of the important advantages to both parties that may result from a free interchange of electric energy between the system of a large industrial establishment and an electric utility system, particularly where the industrial establishment has the characteristics of some of the large steel mills. It is of sufficient importance to warrant its being emphasized again, however, that an interconnection or an interchange contract between a utility and an industrial system must provide for definite profit to both parties if such a contract is to endure.

News
Of Institute and Related Activities

Asheville, N. C., as it appears from the slopes of nearby Beaucatcher Mountain

Summer Convention Program Announced

Offers Timely Technical Topics Attractively Seasoned With Recreation Features 'Midst Scenic Splendors of the Old South

ASHEVILLE, North Carolina, will be host to the 1931 A. I. E. E. summer convention which will be held June 22-26, with headquarters at the Grove Park Inn. An exceptional program combining the annual business meeting, technical sessions, entertainment, and sports, with ample opportunity to see some of the splendor of the mountains surrounding Asheville, has been arranged by the general convention committee. Excellent concrete highways lead from the city in all directions and wind their way over the various mountain ranges to such points of scenic interest as Chimney Rock, Lake Lure, Mount Pisgah, and the Pisgah National Forest and Game Reserve.

Technical and Business Sessions

A selection of specially excellent papers from a wealth of material comprises a technical program of broad scope and current interest. Symposiums comprise three of the sessions; one on the important subject of system interconnections; another on the interesting topic of communication systems for electric utilities; a third dealing with the history of electrical units, the volt, the ampere and the ohm. Four other sessions will present papers describing the latest developments in the fields of power cables, automatic stations, electrical machinery, and research. Annual reports of the Institute's technical committees, reviewing the advances made in theory and practise during the past year, will be available at one of the sessions. A tentative list of the papers for each of these sessions is given in the accompanying tentative program.

The business side of the convention will include the annual meeting of the Institute, a report of the tellers' committee covering election of officers for 1931-1932, the president's address and presentation of prizes for papers. The Lamme Medal, awarded several months ago, will be presented to Dr. William J. Foster, Schenectady, N. Y., "for his contributions to the design of rotating alternating-current machinery."

Entertainment and Sports

Asheville long has been noted for its wonderful climate and the natural beauty of the surrounding country. Attractive trips have been arranged each day for the ladies attending the convention, with luncheons at noted resorts; several bridge games will be arranged.

The president's reception, followed by dancing, will be held on the first night of the convention, Monday, June 22, at the Grove Park Inn. An informal get-together dinner followed by dancing will be held at the George Vanderbilt Hotel Tuesday evening, June 23. Attractive entertainment features will be provided at this dinner. The convention banquet will be held at the Grove Park Inn Wednesday evening, June 24, also to be followed by dancing.

Facilities of the Biltmore Forest and the Asheville country clubs will be at the disposal of those attending. The customary golf and tennis tournaments for the Mershon Cups will be held. The golf courses at Biltmore Forest and

Asheville country clubs will be at their best in June and are sure to prove attractive to golfers and near-golfers.

Both of these clubs also afford fine tennis courts.

Notice of
A. I. E. E.
ANNUAL MEETING

The Annual Meeting of the American Institute of Electrical Engineers will be held in the Grove Park Inn, at Asheville, N. C. at 10 a. m. on Monday, June 22, 1931. This will constitute one session of the annual summer convention, which is to be held in Asheville June 22-26.

At this meeting the annual report of the board of directors, and the report of the committee of tellers concerning the ballots cast for the recent election of officers will be presented.

Such other business, if any, as properly may come before an annual business meeting may be considered.

(Signed) F. L. HUTCHINSON,
National Secretary.

OUTLINE OF PROGRAM

(Eastern Standard Time throughout)

MONDAY, JUNE 22

9:00 a. m. Registration

10:00 a. m. Annual business meeting of the Institute
  Address of welcome by the mayor of Asheville
  Annual report of the board of directors (in abstract) by F. L. Hutchinson, national secretary
  Report of tellers committee on election of officers; introduction of and response from president-elect.
  Presentation of prizes for papers
  Presidential address, by W. S. Lee
  Lamme Medal presentation

2:00 p. m. Conference of officers, delegates, and members
  Qualifying round for Mershon trophy, at Biltmore Forest Country Club
  Tennis at Asheville Country Club

2:30 p. m. Ladies' drive about city followed by tea at Mountain Meadows

9:00 p. m. President's reception—dancing—at Grove Park Inn

TUESDAY, JUNE 23

9:00 a. m. Registration

9:30 a. m. Two technical sessions—
  (a) Symposium on communication services for electric utilities
  (b) Electrical machinery

1:00 p. m. Ladies' luncheon and bridge, at Biltmore Forest Country Club

2:00 p. m. Conference of officers, delegates, and members (continued)
  Sports as scheduled

7:00 p. m. Get-together dinner, at George Vanderbilt Hotel

WEDNESDAY, JUNE 24

9:30 a. m. Two technical sessions—
  (c) Symposium on interconnections
  (d) Symposium on electrical units

12:30 p. m. Directors' luncheon and meeting, at Grove Park Inn

2:00 p. m. Trip to Biltmore house and estate
  Sports as scheduled

7:00 p. m. Convention banquet, at Grove Park Inn

THURSDAY, JUNE 25

9:30 a. m. Two technical sessions—
  (e) Automatic stations
  (f) Cables
  Semi-finals in golf and tennis

2:00 p. m. Technical session—
  (g) Research, selected subjects, technical committee reports
  Finals in golf and tennis

2:30 p. m. Drive to Chimney Rock and Lake Lure for tea

FRIDAY, JUNE 26

All-day excursions, choice of:

(1) Carolina Power and Light Company's Waterville plant

(2) Champion Fibre Company and American Enka Corp.

(3) Mount Pisgah

LADIES PROGRAM

MONDAY, JUNE 22

10:00 a. m. Opening of convention
  President's Address, by W. S. Lee

2:30 p. m. Drive about city followed by tea at Mountain Meadows

9:00 p. m. President's reception—dancing, at Grove Park Inn

TUESDAY, JUNE 23

1:00 p. m. Ladies' luncheon and bridge at Biltmore Forest Country Club

7:00 p. m. Get-together dinner at George Vanderbilt Hotel

Waterville 135,000-kva. hydroelectric plant of the Carolina Power & Light Company

WEDNESDAY, JUNE 24

2:00 p. m.	Trip to Biltmore house and estate
7:00 p. m.	Convention banquet, at Grove Park Inn

THURSDAY, JUNE 25

2:30 p. m.	Drive to Chimney Rock and Lake Lure for tea

FRIDAY, JUNE 26

All-day excursions, choice of trips as scheduled

TRIPS

Friday, June 26, will be devoted to an all-day excursion with a choice of one of the following trips: Carolina Power and Light Company, Waterville plant; Champion Fibre Company and American Enka Corp.; Mount Pisgah.

The Waterville plant of the Carolina Power and Light Company is situated on the Big Pigeon River close to the Tennessee state line. Twelve miles upstream a concrete arch dam, 200 ft. high and about 700 ft. long at the top, forms a reservoir from which water is conducted to the plant through a concrete-lined tunnel approximately 33,000 ft. in length. Construction is in two sections known as the upper and lower levels, connected by a vertical circular section known as the gap shaft. The power house contains three 45,000-kva., 13.8-kv., 400-r. p. m. vertical generator units each directly connected to a 55,000-hp. Francis type waterwheel. The unit system is employed and each generator is connected directly to the step-up bank of transformers without low-voltage oil circuit breakers.

Through the Waterville high-voltage bus an interconnection is formed which establishes a complete connection between the Great Lakes and the Gulf of Mexico. Transmission lines interconnect with the Appalachian Electric Power Company to the North, the Tennessee Public Service Company and Tennessee Electric Power Company to the West, and the Duke Power Company to the South, as well as supplying the Carolina Power and Light Company's load in western North Carolina.

The large Canton, N. C., plant of the Champion Fibre Company is unique in the history of industrial development in that it serves the paper industry as well as the tanning industry. When chestnut wood is employed as the raw material to produce soda pulp the tannin must first be extracted. The tannin extract unit for this purpose has a capacity of 500 barrels of liquid tannin extract per day. Sulphate pulp is produced in large quantities from the hemlock and spruce. Another mill produces high-grade book, bond, tablet, and envelope papers and has a daily capacity of 100 tons. Chlorine used for the bleaching of pulp is produced by an electrolytic plant having a capacity of 70 tons daily. The chief by-products of this industry consists of highly volatile methyl compounds, turpentine, and sodium resinate, obtained from the cooking of pine wood for sulphate pulp.

Mount Pisgah, with an altitude of 5,749 ft. is the principal high point in the Pisgah National Forest and Game Preserve. Its summit affords a panorama view of Buncombe, Transylvania, Henderson, and Haywood counties, overlooking Little Bald, Big Bald, Cold Mountain, and Eagles Nest. The beautiful mountain laurel and rhododendron also will be in bloom during June. This excursion consists of approximately a 60-mile round trip. Delightful meals and hotel accommodations may be secured at the famous Pisgah Forest Inn, near the top of the mountain.

Waterville dam of the Carolina Power & Light Company

RAILROAD RATES

It has been ascertained that in nearly all cases the summer tourist rates are lower than those offered by the convention certificate plan. On this account certificate rates are not being arranged and members are advised to purchase Summer Tourist tickets to Asheville, N. C.

CONVENTION HOTEL RATES

Reservations for hotel accommodations should be made by writing directly to the hotel preferred. Rates for rooms with bath are:

Hotel	Plan	Single	Double (per person)	No. of Guests
Grove Park	A	$12	$10	400
George Vanderbilt	E	3	2.50	400
Battery Park	E	3.50	3	400
The Manor	A	9	8	100

All hotels are within ten minutes' easy driving of the convention headquarters hotel.

COMMITTEES

The general convention committee for the 1931 summer convention consists of the following members, who are officers or chairmen of other committees as indicated: E. P. Coles, chairman; C. E. Waddell, honorary chairman; W. S. Rodman, vice-president; M. E. Lake, secretary-treasurer; R. R. Laxton, assistant secretary-treasurer; A. E. Knowlton, meetings and papers committee; E. S. Lee, sections committee. The following members are chairmen of subcommittees: T. F. Ball, publicity; Mrs. F. Q. Boyer, ladies; W. S. Lee, Jr., hotels and registration; W. E. Mitchell, finance; F. L. Moser, transportation and trips; J. E. Sirrine, sports; and C. E. Waddell, entertainment.

Tentative Technical Program

Tuesday—9:30 a. m.

(A)—Symposium on Communication Services for Electric Utilities

COMMUNICATION SERVICES FOR ELECTRIC UTILITIES, by C. F. Craig, American Telephone & Telegraph Company; R. N. Conwell, Public Service Electric & Gas Company; G. W. Keenan, Pennsylvania-New Jersey Interconnection; and E. C. Briggs.

COMMUNICATION IN THE WESTERN DIVISION OF THE NIAGARA HUDSON SYSTEM, by Colonel William Kelly, Niagara Hudson Power Corporation.

COMMUNICATION FACILITIES OF A METROPOLITAN POWER SYSTEM, by P. B. Juhnke, Commonwealth Edison Company.

COMMUNICATION SERVICES FOR THE NEW ENGLAND POWER ASSOCIATION, by C. A. Booker, New England Power Association; and M. E. Clark, New England Telephone and Telegraph Company.

COMMUNICATION SERVICE OF THE ARKANSAS POWER AND LIGHT COMPANY, by C. E. Stewart, Arkansas Power & Light Company.

Tuesday—9:30 a. m.

(B)—Electrical Machinery

REESTABLISHING EXCITATION OF A LOADED ALTERNATOR IN PARALLEL WITH OTHERS, by D. D. Higgins and E. Wild, Commonwealth Edison Company.

THE CALCULATION OF THE CONSTANTS OF SYNCHRONOUS MACHINES, by L. A. Kilgore, Westinghouse Electric & Manufacturing Company.

Determination of Synchronous Machine Constants by Test, by S. H. Wright, Westinghouse Electric & Manufacturing Company

Transient Oscillations in Distributed Windings, by L. V. Bewley, General Electric Company.

Wednesday—9:30 a. m.

(C)—Symposium on Interconnections

Interconnection Services—Their Classification and Evaluation, by A. E. Bauhan, Public Service Electric & Gas Company.

Interconnection—New England District, by E. W. Dillard and W. R. Bell, New England Power Engineering and Service Corporation.

The Pennsylvania–Ohio–West Virginia Interconnection, by H. S. Fitch, West Penn Power Company.

Interconnection Development and Operation, by G. M. Keenan, Pennsylvania-New Jersey Interconnection.

Wednesday—9:30 a. m.

(D)—Symposium on Electrical Units

International Standard of Electromotive Force and Its Low-Temperature Coefficient Form, by Marion Eppley, The Eppley Laboratory, Inc.

Design of Potentiometers, by I. Melville Stein, Leeds and Northrup Company.

Electrical Units and Their Application, by L. T. Robinson, General Electric Company.

History of the Unit of Electrical Resistance with Special Reference to Mercury Standards for the Ohm, by H. B. Brooks, National Bureau of Standards.

Thursday—9:30 a. m.

(E)—Session on Automatic Stations

Supervisory Control Systems, by O. K. Marti, American Brown Boveri Company.

Supervisory Control for A-C. Electrified Railroads, by C. P. West, Westinghouse Electric & Manufacturing Company; and H. C. Griffith, Pennsylvania Railroad Company.

Automatic Combustion Control, by C. H. Sanderson and E. B. Ricketts, New York Edison Company.

Operating Experience with Automatic Stations, by F. F. Ambuhl, Toronto Hydro-Electric System; and Garland Stamper, Columbia Engineering & Management Corporation.

Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control, by R. M. Stanley, Byllesby Engineering & Management Corporation.

Thursday—9:30 a. m.

(F)—Cables

Economics of High-Voltage Cable, by D. W. Roper, Commonwealth Edison Company.

Characteristics of Oil-Filled Cable, by G. B. Shanklin and F. H. Buller, General Electric Company.

A Complete Oil-Filled Cable System—Condenser Joints and Terminals, by R. W. Atkinson and D. M. Simmons, General Cable Corporation.

Insulation Variability—Its Influence in Determining Breakdown Voltages, by D. C. Holmes, West Virginia University.

Thursday—2:00 p. m.

(G)—Research and Selected Subjects Technical Committee Reports

Extinction of Short A-C. Arcs, by T. E. Browne, Jr., Westinghouse Electric & Manufacturing Company.

A Corona-Tube Voltage Regulator, by H. W. Dodge and C. H. Willis, Princeton University.

Residual Air and Moisture on Impregnated-Paper Insulation—III, by J. B. Whitehead and F. Hamburger, Jr., Johns Hopkins University.

The Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes, by D. C. Jackson, Jr., University of Kansas.

Arcing Faults on Transmission Systems, by J. R. Eaton, Consumers Power Company; J. K. Peck, N. E. L. A.; and J. M. Dunham, American Telephone & Telegraph Company.

C. E. Grunsky to Speak at Pacific Coast Convention

C. E. Grunsky of San Francisco, internationally known to engineering circles, and popular and well-beloved as president (second term) of the American Engineering Council, will be the feature speaker and an honor guest of the forthcoming Pacific Coast convention. Thus Mr. Grunsky will lend his rare talent to the already indisputable attractiveness of the convention's technical program, while adding the charm of his own personality to the attractive natural beauties of the Lake Tahoe region, so sure of appeal to the "tired engineer" and his family attending the Pacific Coast's "vacation convention."

August 25-28, 1931, are the dates set for the convention, carefully chosen to fit as nearly as possible the opening dates of fall school terms and to permit college students to attend without missing classes, and families to fit the convention into vacation plans without interference with the children's school activities.

D. I. Cone, chairman of the convention technical program committee, has announced that there will be four technical sessions, two student sessions, and one evening session, promising a particularly well-balanced, interesting and timely technical program. A. G. Jones, chairman of the convention entertainment committee, has reported that the proposed entertainment features include a barbecue supper, steamer rides around Lake Tahoe, several special features designed exclusively for the ladies, and participation in a colorful street show and dance put on by the resort village.

A. S. T. M. to Exhibit Testing Apparatus and Machines

For the first time in history, the American Society for Testing Materials will sponsor an exhibit of testing apparatus and machines in conjunction with its annual meeting to be held at The Stevens Hotel, Chicago, June 22-26. This exhibit, in which government, institutional, and private laboratories are expected to participate, will display equipment used in the testing of materials and products including recording, control, metallographic, optical, chemical, pyrometric and physical devices, fatigue machines, distributors, etc., exhibited by the leading companies in these fields, as well as by foreign companies covering practically every phase of the testing field. Another unique feature of the exhibit will be participation by certain of the society's committees; they have signified their intention of showing apparatus developed for special committee work, not yet commercially produced, but developed for specific tests and determinations.

A. A. A. S. and Associates Plan Week of Meetings

Launching the plan of holding annually a summer meeting of truly national character, the American Association for the Advancement of Science, together with associated societies, is planning a series of meetings, the first of which will be held in Pasadena, June 15-20 inclusive; the 1932 meeting will be in New Haven, Connecticut; the 1933 meeting in Chicago; and the 1934 meeting back to the Pacific Coast in San Francisco.

At these meetings, each group extending over the period of a full week, scientific sessions will be confined chiefly to the mornings, with the emphasis of the session on symposia; afternoons to be given over to discussion, personal contacts and excursions. Both Professor Thomas H. Morgan, (Calif. Inst. Tech.) retiring president, and Professor Franz Boas, (Columbia, Miss.) recently elected president of the association, are planning to attend the 1931 meetings.

Special round trip rates will be offered by the railroads, making the traveling expense from New York and return approximately $140.00; from Chicago, $90.00. A preliminary program giving the plans in greater detail will become available by mail as soon as sufficient information can be assembled from sections and affiliates.

Summary of Some Pittsburgh Discussions

ONLY discussion given at the meeting and submitted in writing in accordance with A. I. E. E. rules governing it is summarized; complete discussion, together with all papers so approved, will be published in the TRANSACTIONS. The titles of the papers and the names of their respective authors were published on page 140 of the Feb., 1931, issue of ELECTRICAL ENGINEERING.

Alternating-Current Low-Voltage Networks

Six papers were presented dealing with two phases of the network problem. Three of these gave attention to what might be termed the theoretical or fundamental side of the question, while the others described new installations either recently completed or under way.

CABLE BURN-OFF CHARACTERISTICS

W. R. Bullard discussed the subject and he believed the most important conclusion was that single-conductor buried cable of the non-metallic armored type had better burn-off characteristics than the other types of construction tested. He also brought out that with the use of this type of cable the necessity for good burn-off characteristics might be eliminated.

W. A. Del Mar discussed this subject explaining that there were many types of non-metallic trench cable being manufactured and purchased on various kinds of specifications, some of which merely describe one type or another, while others are based only on performance tests. He expressed the need of coordination in this field and advocated a course of procedure whereby the devising of tests would be a joint effort of the operating and manufacturing engineers. The designs of cables to meet these tests should be left to the cable maker.

B. M. Jones discussed this subject from the economic standpoint of planning an a-c. low-voltage network with provisions for sufficient spare capacity to burn clear a fault of the most severe type in the weakest spot with any one particular supply feeder out of service.

ARCS IN LOW-VOLTAGE A-C. NETWORKS

W. R. Bullard in his discussion of this subject explained that his experience agreed with the statement in the paper presented that pre-carbonization of cable insulation destroyed its arc-extinguishing features.

W. G. Dow discussed the differences in the values of the arc-reignition characteristics brought out by the two papers and set forth reasons for the difference in the results.

T. E. Browne, Jr., discussed "The Reignition of Metallic A-C. Arcs in Air." He commented on the point that the oscillograms were the first obtained that had shown directly on a time axis just what occurs to the current and voltage of a short a-c. arc during the elusive-current zero period.

A PRIMARY NETWORK

E. R. Hendrickson in his discussion of the subject inquired if the primary network would represent the correct solution for service to a territory of low- or medium-load density, where because of the importance of continuity of service or future load growth, a secondary network would be required in the future.

W. R. Bullard in his discussion of the subject advocated using a type of system which would eliminate the intermediate transformation and supply the distribution transformers directly with generating station or transmission terminal substation voltage. Such a system would have the advantages of simplicity and greater economy.

H. Richter discussed the paper from the standpoint of developments made in the apparatus employed. The two 1,500-kva. transformers are the largest subway-type transformers thus far produced and the regulators so far as is known are the first of the subway type built in this country.

A. H. Sweetnam discussed the subject and the planning which lead up to the adaption of a 4,000-volt network system to supply a certain area. Estimates were made of the relative cost of supplying this area by means of a 4,000-volt network or the construction of a new substation. The economic study was extended to cover ultimate load requirements and it was found to favor the 4,000-volt network system with a saving of 20 per cent capital investment.

In contrast to the foregoing paragraph H. L. Wallau discussed a comparative estimate made five or six years ago which indicated a relative investment of 100 per cent for the radial type *vs.* from 106 to 118 per cent for the networked type.

G. M. Miller in his discussion of this subject explained that the primary network is a long step forward in a scheme to reduce investment and operating costs, to provide improved service, and give greater flexibility in handling increases in load.

THE PHILADELPHIA A-C. NETWORK SYSTEM

H. Richter discussed this system and drew attention to the length of time required for transformer secondary fuses to clear primary faults. He believed that the automatic protector would answer this requirement much better than the transformer secondary fuses.

System Grounding Problems

In the session devoted to grounding, relaying, and transmission problems five papers were presented. One of these was in reality a subcommittee report covering grounding practises.

SYSTEM GROUNDING PROBLEMS

E. C. Stone capably analyzed the second report of the subject committee on grounding. A comparison with the first report of eight years ago indicated no radical changes but some interesting trends, one of which was toward the solidly-grounded system.

H. M. Trueblood discussed "Reactance of Transmission Lines with Ground Return" and analyzed the terms in Carson's expression on the hypothesis that the earth is of infinite conductivity.

P. A. Jeanne discussed this paper and expressed his beliefs that the method of developing the formulas for the zero sequence impedance as outlined in the appendix is preferable to the method given in the main body of the paper because it involved only the use of complete ground return circuit impedances.

C. L. Gilkeson presented a discussoin prepared by F. J. Grueter on the same paper. One of the points discussed was the simplifying assumption made in the development of the method of calculating zero-sequence impedance that uniform current exists along the length of the ground wire. This condition holds only when the ground wire is terminated in impedances to ground which are small compared to the resistance to ground of the tower footings. G. Waschick in his discussion of this paper also referred to the same point.

J. E. Clem discussed "Power System Voltages and Currents under Fault Conditions." He suggested a classification based on overvoltages for grounding systems, or circuits, as follows: solidly-grounded, effectively-grounded, non-effectively-grounded, and isolated. For this classification certain auxiliary terms were defined.

H. W. Bibber's discussion of this paper was read by J. E. Clem. For those who wished to go further into the subject in a more detailed and mathematical manner he suggested an article in the May 10, 1930, *Revue Géneralé d'Electricité* by J. Fallou.

C. A. Powel read Mabel Macferran's discussion on "Simultaneous Faults in Three-Phase Systems," which clearly pointed out the practical value of the paper. J. E. Clem read a discussion prepared by H. W. Bibber on this paper. It indicated that Miss Clarke's methods of calculating simultaneous faults on grounded systems could be extended to include the determination of currents and voltages in isolated neutral systems.

Closing
Session Discussion

The closing session was devoted to "selected subjects" concerning industrial power applications and communication developments.

R. R. Johnson discussed "A Modern Electrified Dairy Plant" and explained that the change-over of which the authors spoke was conceived approximately six years ago. Another interesting point cited was that only five unarranged outages, totaling one hour and three minutes, have occurred since the substation was installed in 1925.

One of the interesting points described by A. T. Ruttencutter in connection with his discussion of the paper was the application of the "Electropure" process of pasteurizing milk. B. W. Faber also discussed this paper and inquired if the pasteurizing of milk increased the quality of the milk.

J. L. Woodbridge discussed "Power Supply for Telephone Systems" and described the developments in the design and application of the storage battery for this service. I. R. Smith in his discussion of this paper described and illustrated with lantern slides the development of the dry disk copper oxide or Rectox rectifiers for the various applications described in the paper. Efficiency and life test performance curves for these units were also shown.

K. C. White discussed "Power Supply for Telephone Systems." He explained that the Pennsylvania Railroad had applied several of the power plants described in the paper to a rather extensive dial telephone system in the Western Pennsylvania and the Eastern Ohio areas. These automatic power plants have greatly reduced the maintenance required resulting in a smaller operating personnel, better voltage regulation, longer battery life, and practically fool-proof operation. R. L. Dunlap in connection with the discussion of this paper described the advantages accruing from the installation of some of the 72 automatic power plants installed in the Pittsburgh territory.

C. S. Alt discussed this paper as well as "Telegraph Power Plants." He described the special requirements for emergency engine sets for this particular service, such as the ease of starting, quietness, freedom from vibration, and safety features.

In connection with discussion on "Telegraph Power Plants," G. H. Kendricks described interestingly some of the early power plants of the Western Union Service in Pittsburgh and told of some of the difficulties encountered.

Overseas Telephone Service

J. P. Scott discussed this subject and inquired as to the total per cent of lost time due to all causes; also as to how often magnetic storms were usually experienced.

W. C. Hecht asked how the practical operating hours were affected by the differences in time of day at the terminals.

N. S. Hoff inquired as to the steps involved and the length of time required from the conception of a radio circuit to the establishment of actual service.

In other discussion on this paper W. L. Schafer referred to the gains obtained by the use of the directive antenna arrays at the transmitter and receiver, and inquired as to the possibilities of further substantial gains by such means.

Other equally interesting and pertinent questions were asked during the discussion of this paper which was presented by F. A. Cowan.

Engineers' Economic Conference To Be Held by Stevens Institute

An ECONOMIC conference for engineers will be held from Aug. 30 through Labor Day, Sept. 7, 1931, at the engineering camp of Stevens Institute of Technology near Johnsonburg, Warren County, New Jersey. The engineering alumni of Columbia University and the alumni of Stevens, under whose joint auspices the conference will be held, will welcome to the camp graduates of other colleges and younger members of the national engineering societies. The hours for lectures, conferences, and round-table discussions by some of the leading economists and engineers of the country are to be scheduled so as to permit the men in camp to make full use of the camp's unusually good facilities for land and water sports.

The serious part of each day's program will have two main elements: in the morning the lectures and discussions will deal with "The Dollar Factor in Engineering," or "Technique in Calculations Involving Money;" at the open forum and round-table discussions in the evening, elements in depression, and seasonal and cyclical fluctuations will be considered. The Carnegie Corporation, on the recommendation of the American Association for Adult Education, has endorsed the project through a grant of $1,500.

The Economic Factor in Engineering

Lectures and conferences scheduled for the morning hours will be under the direction of William Duane Ennis, head of Stevens' department of economics of engineering who will be assisted by members of the Stevens and Columbia faculties. In his outline of the subjects to be dealt with Prof. Ennis remarks that:

> Every engineer knows that a point is reached in his problem where commercial factors, so-called, must receive consideration. Too often from this point the problem is relegated to another than the engineer; perhaps to a lawyer, perhaps to a "business man." No sufficient reason for this exists. There is a body of principles underlying the evaluation of commercial factors just as there is a mass of doctrine back of engineering factors. In the setting of an interest rate, no less than in the determining of a stress, there is a mass of facts and coordinations, not scientific, perhaps, but nevertheless organized. The course proposed for the coming summer aims to develop some of the principles which are fundamental in applying money factors to engineering problems.

The Business Cycle

In addition to the morning series of lectures and seminars on the "money factor" in engineering, the economic conference is planned to include eight or nine evening lectures and round-table discussions on the business cycle. Four major questions of business depression are proposed for consideration:

1. What is the most significant statistical description of what has happened since the fall of 1929?
2. What statistical approach looks most hopeful for forecasting or for starting a public works program?
3. What is the most significant explanation of what has happened?
4. What to do about it.

The first two questions, bringing out a description of a period of depression, will be discussed by leading financial and government analysts. The third will be submitted to investigators in theoretical economics associated with university faculties and research staffs of private corporations. Under the fourth topic, emergency relief, industrial stabilization, unemployment insurance, and long-range planning will be debated by men who have been actively engaged in solving such problems for industrial organizations and civic committees.

Engineers interested in attending this conference should communicate promptly with Stevens Institute of Technology, Hoboken, New Jersey. Accommodations at the camp are limited.

Mining Engineers Report Upon Russian Living Conditions

AMERICAN engineers considering employment in the United States of Soviet Russia are face to face with a stern situation according to an exhaustive report presented to and approved by the board of directors of the American Institute of Mining and Metallurgical Engineers March 20, 1931. The investigation was authorized by the A. I. M. E. board of directors Nov. 21, 1930 and the report was published on pp. 207-8 of *Mining and Metallurgy* for April 1931. The following excerpts are taken from the published report:

General Observations

"The government in Russia is undertaking an experiment completely at variance with accepted American procedure by methods wholly contrary to American ideals. The country has a form of government comparable with the most drastic type of martial law as Americans understand that term. Industrial conscription forces every individual into service.

"The Soviet Government is seeking to industrialize in the next few years a backward country under a program which, if completed, will place Russian industrial production on a plane with or above the present production of the United States in the major basic industries—a plane which has been attained only by decades of orderly progress. The first step of their program is the Five-Year Plan now in course of execution. The Soviet Government proposes to accomplish its aims not through private initiative, but through direct government action. . . .

"The success of the plan is absolutely essential for the continuation of the Soviet regime and nothing—not even human life—is a barrier to their efforts to force the plan to success. A wholly artificial condition of living has been created. Individual initiative and the reward for effort are completely submerged under despotic discipline and drastic penalties. . . .

Living Conditions

"Food, generally speaking, is scarce; some, of very poor quality. It is extremely expensive unless bought at government stores with a government food card. While conditions are not uniform throughout Russia, in Moscow and Leningrad long lines of people are obliged to stand in front of these stores waiting to enter. . . .

"Individuals proceeding to Russia at this time must be prepared to assume the role of pioneers, *i. e.*, stand hardships and discomforts not met with in other countries. Such conditions can be tolerated by some, but others will find them unbearable. They may find themselves impaired in health, become discouraged and unhappy, resulting in regret for their decision to leave a peaceful civilized country despite the opportunity for more pay than now attainable at home. Without question, an engineer should not take children into Russia. Most people familiar with conditions there strongly advise against the taking of wives, unless they be strong, healthy, robust individuals, accustomed to discomforts and inclined to enjoy overcoming difficulties and the fighting of adverse conditions.

"It would be well before accepting employment to confer with several engineers who have worked in Russia under comparable conditions.

Legal Status and Personal Safety

"An individual accepting employment under the Soviets must appreciate that he is working for an autocratic government. The United States has no diplomatic relations with Russia and there is no United States ambassador or consul to whom he can appeal if he feels himself wronged.

"Adequate reasons may develop for the breaking of a contract, but still the government has the arbitrary power to take away passport and food card, and/or prevent the employee from leaving the country. In such case great difficulty may be experienced in subsisting. The engineer may be fined or forced to do menial work in punishment for alleged breaking of his contract.

"Up to the present foreigners have been safe in Russia, but will this continue to be the case? Fear is entertained that if the five-year plan should not eventuate as represented to the people, or if some plant or installation should fail to deliver anticipated results, the Soviets will seek a "scapegoat." If so, who would be more suited to that role than the foreign engineers in charge of that particular piece of work? Many people have been executed or imprisoned as "scapegoats." So far as we know, the victims thus far have been Russians; but should desperate conditions arise, may not summary treatment be extended to the foreign elements? . . .

"What would be the position of a member of the profession upon return to the United States? . . . Is the experience to be gained in Russia apt to be useful? From numerous directions we hear of a lack of organization, of changing of plans on the whim of some committee, interruption of operations because some official considers another piece of work of more importance. The engineer in charge cannot on his own authority discharge or dispense with the services of his subordinates. It is doubtful if work carried on under such conditions provides experience an American engineer can capitalize upon his return home, and it may even depreciate his effectiveness as an executive.

Recommendations Concerning Service Contracts

"So far we have only enumerated some of the conditions in Russia that suggest points to be considered (by an engineer) when deciding to accept employment in that country. *If he decides that his particular situation is such that he must accept Russian work regardless of the known unfavorable conditions*, then he should if possible give preference to employment with some large American contractor or engineering firm, rather than attempt an individual contract with the U. S. S. R. . . .

"While the matter of performance of an employment contract by the Soviets is a matter of faith, on account of the impossibility of bringing any dispute before an American court, still as far as we know they have thus far shown a disposition to live up to the *letter of the contract*. This being so, it becomes important that the contract terms should embrace every possible contingency. No dependence whatever should be placed on verbal statements or assurances. It has been found repeatedly that assurances made here have no force whatever when the employee arrives in Russia.

"Whether going as an individual or as a member of a group, one should see that the following points, among others, are provided for:

"(a) Adequate provision for first-class transportation and expenses from America to place of employment *and return*.

"(b) . . . He should insist on receiving as large a portion as possible, certainly not less than 50 per cent of his remuneration, in dollars to be deposited or paid as directed in the United States. It must be remembered that foreign money can be brought out of Russia only to the extent to which it was taken in, less the amount the authorities decide he should have spent while in Russia. After residing in Russia for a certain length of time, no foreign money can be taken out. While a certain amount in Russian currency can be sent out, it has only a greatly depreciated value in foreign countries.

"(c) . . . Visitors to Russia are required to spend a certain minimum per day and the engineer should inform himself to what extent these regulations apply in his case.

"(d) A non-resident citizen is subject to our Federal income tax, but should be free from taxation by the Soviet Government on amounts deposited in this country to the citizen's credit. A definite understanding should be had as to the amount of taxes on salaries paid in Russia, as well as on all other taxes.

"(e) Provision of living quarters, domestic servants, water, heating, light, cooking and sanitary arrangements, either free of charge or at a definite price.

"(f) Fuel for heating and cooking and price thereof.

"(g) Supply of food and privilege of purchasing food, clothing and other supplies at commissaries established for foreign diplomats and engineers.

"(h) Privilege in regard to the taking in and importing into Russia later of foodstuffs, clothing, toilet articles, etc., free of duty coupled with *guarantee of arrival.*

"(i) Outlining of duties and responsibilities of service to be renderd.

"(j) The conditions under which employees are privileged to resign with safe conduct and expenses back to the United States, etc.

"(k) Discontinuance at one job not to give Soviet the privilege of transference to another.

"(l) Various Soviet industrial organizations, operating through the Amtorg Trading Corporation in New York, engage American engineers and technicians to work in Russia. As there are no relations between the government of the United States and that of the Soviet Union, the signature of the Amtorg for itself as an American corporation should always be obtained to any contract.

"The foregoing observations should be regarded only in the light of general suggestions. They are intended to call attention to the unusual circumstances surrounding the Russian situation; each case will require more individual treatment than is possible in a general report. —*Respectfully submitted, Henry Krumb, chairman; Lucius W. Mayer, J. V. W. Reynders, Edgar Rickard.*"

Electric Steam Generator For Sterlization Processes

Packed heat from a new type of electric steam generator displaces steam from high-pressure mains, it is declared by Howard Bidwell and Linus H. Jones of the Massachusetts Agricultural Experiment Station, Amherst, in a report to the American Chemical Society.

"The new electric generator," the report says, "is applicable for use with hospital sterilizers, pressure-cooking retorts, or in any industrial process where a large quantity of steam is necessary for a short period of time.

"There are many processes in the scientific and industrial fields that require large amounts of steam for periods of short duration. High-pressure steam is expensive and its cost is becoming so excessive that this method is almost prohibitive during the non-heating months. There is also a labor cost if the law of the state demands a licensed operator.

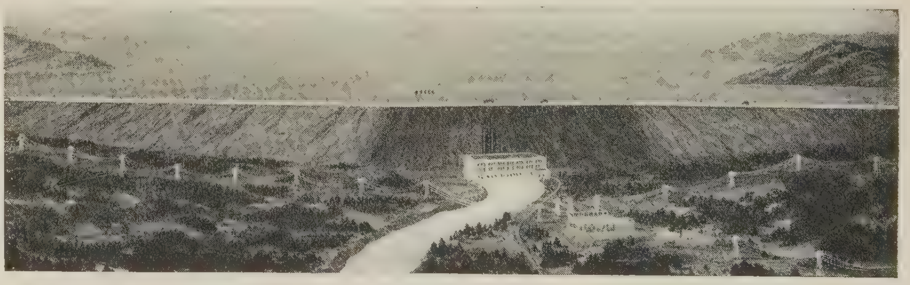
"This generator has a reservoir in which heat is packed and stored. The result is that within thirty seconds from the time of closing the autoclave the required sterilizing pressure is registered. This may be obtained at any time by throwing a switch and opening two valves.

"The principle employed in the action of this boiler is that law of physics which governs the varying boiling points of water under different pressures. Depending upon the water capacity of the generator, irrespective of the steam space, any desired volume of steam at a lower pressure can instantly be made available by suddenly relieving the pressure on the generator.

"The use of fuel or electric steam generators that build up a sterilizing temperature in a retort decreases the working efficiency of the autoclave and its attendant. Time consumed in heating and cooling a large volume of water means time lost. The most satisfactory method is that which gives a sterilizing temperature immediately and allows one to stop the supply of heat as soon as the charge has been sterilized. The new electric steam generator gives all that can be desired as a source of steam and heat."

Saluda Completed To 162,500 Kva. Capacity

Completion of the Saluda development of the Lexington Water Power Company, subsidiary of the Associated Gas & Electric Company, injects another important factor into the industrial power situation of the southeastern states. The installation is on the Saluda River nine miles above its junction with the Broad River at Columbia, S. C., where a 7,838-ft. earth dam with its crest at El. 372,208 ft. above the river bed forms the Lake Murray reservoir which is 41 mi. long and 14 mi. wide at its widest point. With an area of 78 sq. mi. this reservoir has a capacity of some 2,340,000 acre ft., which is said to represent 200 million kw-hr. at normal rates of withdrawal under average conditions. At its base at the power house the dam is 998 ft. thick; 1,150 ft. thick at its base at its maximum point, and contains 11,000,000 cu. yd. of earth fill.



Artists sketch of Saluda development in South Carolina

The present installation which represents two-thirds of the expected ultimate plant capacity includes four 40,625-kva., 0.8-power-factor, 13.8-kv., three-phase, 60-cycle, 138.5-rev. per min. vertical generators direct-connected to 55,650-hp. Francis turbines, designed to develop full rated horsepower at 180-ft. head with full gate opening. The generators are of the single-bearing overhung-rotor type, having a thrust and a steady bearing in the same oil pot beneath the rotor.

At the present time, surge tanks are installed only for units Nos. 1 and 3, which units it is intended will do the regulating for the plant with high-speed governing equipment, whereas units Nos. 2 and 4 are expected to run practically at constant load with slow-speed governing.

The plant output is stepped up to 125.6 kv. through 40,000 kva. outdoor transformer banks at the plant, and carried approximately a thousand feet down the stream to the high-voltage switching substation whence it is distributed throughout the interconnected Associated Gas & Electric system.

Engineers for the project were Murray & Flood, and W. S. Barstow & Company, Inc.; Albert S. Crane was consulting engineer. Designs for the dam, conduits, intakes, surge tanks and spillway were made by the J. G. White Engineering Corporation, and the designs for the power house and substation were worked out by W. S. Barstow & Company, Inc. The dam, conduits, and intakes were built by the Arundel Corporation, and the power house, spillway, and substation, by W. S. Barstow & Company, Inc. The steel-pipe conduits were furnished by the Reeves Brothers Company; the penstocks and surge tanks by the Chicago Bridge & Iron Company; the intake gates by Phillips & Davies, Inc.; the turbines, butterfly valves and Radial gates by the S. Morgan Smith Company; the turbine governors were built by the Woodward Governor Company; the generators by Westinghouse Electric & Manufacturing Company; and the transformers by General Electric Company.

Special Laboratory Lighting at Penn State

An UNIQUE and important improvement in laboratory lighting was demonstrated recently in the completion of a new building at Pennsylvania State College. In this, lighting is provided by direct prismatic glass globes, the lower half of each being color-correcting, blending well with daylight and entirely satisfactory for night use. Sufficient unmodified light passes through the upper half of the globe to illumine the ceiling, and overbalance the unfavorable appearance at night of daylight lamp equipment, at the same time in no way interfering with the identification of colors in specimens being studied. With this type of fixture 300-watt lamps with approximately 11-ft. centers produce an intensity of from 18 to 20 foot-candles on the tables. . . . (Contributed by Prof. D. L. Markel, State College, Pa., through the A. I. E. E. committee on the production and application of light.)

N. E. L. A. Annual Convention June 8-12

The Atlantic City Auditorium and Convention Hall will be the headquarters of the fifty-fourth annual gathering of the National Electric Light Association.

The convention will open officially June 8, although the registration desk will be active June 6 and 7; the exhibition Monday, June 8, at 9 a. m., continuing daily throughout the convention dates. Special features of the convention's program will be a "national employee speaking contest" on Monday with award of the prize on Thursday. On Tuesday, June 9, there will be a "seaview day" for the ladies. A diversive program fitted to this special season but in no way neglecting technical values will be offered by this convention.

Purdue University Receives Airport Site

In proof of his faith in the future of aeronautics and as another evidence of his foresight for Purdue University, David E. Ross, president of the board of trustees of the university, has purchased and deeded to the university three tracts of land totaling 157 acres, to be developed as a Purdue airport. The tract which is level and free of trees lies a half-mile southwest of the campus and adjoins Edgewood farm owned and operated by the university. This if it were found desirable to do so at a later date could be used as part of the landing field giving a combined tract of 317 acres on level land.

The area purchased by Mr. Ross has been officially inspected by representatives of the U. S. Department of Commerce and received high approval for aircraft purposes. Adequate markings have been placed for the new airport and the field has been included in the new airport map of this region prepared by the Department of Commerce.

Triennial Montefiore Prize Award Now Open

Constituting interest on 150,000 Belgian francs, distributed triennially in international competition for the best original work presented on scientific advancement and progress in technical application of electricity in every field, the Montefiore prize award now is open again to candidates.

To be eligible an achievement must have been made public at some time during the three years immediately preceding the period of award. Papers either signed or anonymous are acceptable in manuscript or reprint form; they must, however, have been edited in either French or English; also, all manuscripts must be typewritten.

By a four-fifths vote of the board of examiners composed of five Belgian and five other electrical engineers, one-third of the amount available may be designated as an unsecured loan to a person whose work does not fall completely within the ritual of the governing program but which demonstrates a new thought in connection with development of importance in the sphere of electricity.

Can You Supply These Transactions?

The engineering department of the University of Tennessee, through its trustee Paul J. Kruesi, is making an appeal for the following back volumes of A. I. E. E. Transactions:

1884-87	(inclusive of vols. I, II, III and IV; vols. I and III desired if available in separate unbound form)
1887-88	(vol. V)
1888-89	(vol. VI)

Mr. Kruesi will be grateful to anyone willing to spare these copies to complete the University's library records. Address Miss Laura Kersey, Librarian, Engineering Library, University of Tennessee, Knoxville, Tenn.

Outdoor Generators For New Bagnell Dam

First shipments on an order for waterwheel generators to be used at the new Bagnell Dam on the Osage River, Missouri, are being made from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, to the Union Electric Light and Power Company, St. Louis, Mo. The six generators are of the so-called outdoor type and will be built into the foundation of the spillway. Instead of the usual power house, the units will simply be covered with large cast iron lids which may be removed as desired by a large traveling crane. Only the controls will be housed inside of rooms built into the wall of the dam.

In operation the generators will become a part of the 201,000-hp. development on the Osage, the Bagnell Dam being a structure 148 ft. high from bedrock to highway and forming a reservoir 129 mi. long with an area of 95 sq. mi. and 1,300 mi. of shoreline. In the development of this reservoir it has been found necessary to move an entire town four miles to higher ground. The Bagnell Dam is located 130 mi. southwest of St. Louis.

Engineering Foundation

Education Research Committee Established

Engineering education during the past decade has received much serious attention from engineers, educators, industrialists, philanthropic foundations, and various government agencies. Through the Society for Promotion of Engineering Education, Engineering societies have cooperated with engineering colleges and because of the interest expressed by its founder societies and the need for help in prosecuting the work which the Education society has had in hand, the Engineering Foundation has devoted much energy to the subject. Encouraged by discussion at its recent meetings and conferences which were attended by many men prominent in education, industry, and engineering, and advised by a small group of educational research men, the Foundation established an education research committee:

Harvey N. Davis (chairman), president of Stevens Institute of Technology; A. S. M. E.

Walter F. Whittemore, Hotel Woodstock, New York; A. S. C. E.

William B. Plank, Lafayette College; A. I. M. M. E.

Harold B. Smith, Worcester Polytechnic Institute; A. I. E. E.

Robert I. Rees, assistant vice-president American Telephone and Telegraph Company; Society for Promotion of Engineering Education.

Alfred H. White, professor of chemical engineering, University of Michigan; A. I. C. E.

Alexander R. Stevenson, Jr., General Electric Company, Schenectady, New York; The Engineering Foundation.

This committee was charged with ascertaining the attitude of the engineering societies toward a project to comprise:

(a) Fundamental research in engineering education.

(b) Vocational guidance, especially for youths in preparatory schools, including booklets giving information about engineering.

(c) Empirical investigations of objective tests and comprehensive examinations.

In preparation for outlining a project of reasonable dimensions the committee is making a preliminary study of:

(1) Placement of graduates of secondary schools (and other young persons) in engineering colleges.

(2) Objective tests, for various purposes.

(3) Placement of engineering college graduates in industry and business.

(4) Correction of the maladjustment of certain students and graduates to their social and other environments.

(5) What Engineering Foundation can do to be to engineering what the Chemical Foundation has been and is to chemistry, in extending the public's knowledge and appreciation of engineers and their work.

Standards

I. E. C. Announces Revision of Electrical Machinery Rules

Final approval of the I. E. C. *Publication No. 34* containing the revised I. E. C. rules for electrical machinery was given by the U. S. National Committee of the International Electrotechnical Committee at a meeting held February 6, 1931. In its present form this publication was drawn up at the I. E. C. plenary meeting held at Oslo in July 1930; it represents, however, the culmination of ten years of continuous effort, during which time it has been the subject of debate at seven formal international I. E. C. meetings.

The revised publication represents the agreement of national committees of the I. E. C. in more than a dozen countries, and constitutes an international consensus of opinion concerning the more usual requirements of electrical machinery standards similar to those now a part of the various national standards, such as the A. I. E. E. Standards in the United States, the B. E. S. A. Standards in Great Britain, and the V. D. E. in Germany. It covers all sizes of transformers and rotating electrical machines except traction motors, and supersedes the 1920 edition. Other I. E. C. Standards publications include the following:

Number	Title	Price
27.	International Symbols (first part) Letter Symbols	$0.50
28.	International Standard of Resistance for Copper	0.50
34.	**I. E. C. Rules for Electrical Machinery**	**1.00**
35.	International Symbols (second part) Graphical Symbols for Heavy-Current Systems	1.00
37.	Standard Dimensions of Bayonet Lamp Sockets and Caps	0.25
38.	I. E. C. Standard Voltages	0.25
39.	International Rules for Traction Motors	0.25
41.	I. E. C. Publication on the Testing of Hydraulic Turbines	0.50
43.	I. E. C. Recommendations for Alternating Current Watt-Hour Meters	0.50
44.	I. E. C. Recommendations for Instrument Transformers	0.50

Copies of any of these publications may be obtained from the secretary of the U. S. National Committee, I. E. C., 33 West 39th Street, New York, N. Y. They may be obtained also from the central office of the commission by addressing Mr. C. le Maistre, 28 Victoria Street, London, S. W. 1, England. In ordering this literature it is essential that the request be accompanied by the proper remittance.

How to Obtain the New Standards Yearbook

The 1931 volume of the Standards Yearbook compiled by the National Bureau of Standards and containing authentic and carefully investigated information on (I) Standardization in transport (in symposium form); (II) International standardizing agencies; (III) National standardizing agencies; (IV) Federal standardizing agencies; (V) National Bureau of Standards; (VI) Municipal, county, and state purchasing agencies; (VII) General standardizing agencies; (VIII) Standardizing activities of technical societies and trade associations; (IX) Bibliography on standardization; and (X) a complete Index, is now off the press. In the transport division (I) falls such facts as relate to research and experiment in aviation, automotive, and highway development and safety; railroads, pipe lines, elevators, marine navigation, speech and power transmission, and other important government activities. The volume also reports an annual bibliography on standardization prepared by the Library of Congress. The price of the book for domestic distribution is $1.00; it is obtained by addressing the Superintendent of Documents, Government Printing Office, Washington, D. C.

New Standards Data.—A new compilation of data entitled, "Measurement Units and Standards," has been issued recently by the American Institute of Weights and Measures; a copy of this book may be obtained gratis by applying to the Institute, William E. Bullock, secretary, 33 Rector Street, New York. In addition to the data on units and standards, the book contains an article recommending *timex* and *spacex* as names for the Einstein specialization of basic time and space. It also contains a description of the difference between a *unit* and a *standard*, prompted by the lack of unanimity existing in reference publications.

High British Award to Francis Hodgkinson

Francis Hodgkinson (Asso. '02), consulting mechanical engineer for Westinghouse Electric & Manufacturing Company and well known in marine circles for his many contributions to efficiency by improvement of steam-driven machinery and electrical apparatus, has received the Willans Premium, a high British engineering honor awarded by the Institution of Mechanical Engineering, London. The award was given for the best paper published in the *Proceedings* of the Institution from 1925 to 1930 inclusive, and is being forwarded to Mr. Hodgkinson in the form of a gold medal. His prize-winning paper was entitled "Journal Bearing Practise."

The Willans Premium which may be awarded in the form of medals, books, or cash as the council may determine, was established 1897 to perpetuate the name of Peter William Willans for services rendered engineering and electrical science. It is awarded alternately by the Institution of Mechanical Engineers and the Institution of Electrical Engineers, for the best original paper coming before either institution, and dealing with—utilization and transformation of energy treated especially from the point of view of efficiency and economy. The award is made triennially, but may be carried over according to the judgment of the governing board.

FRANCIS HODGKINSON

Mr. Hodgkinson was associated with the late Sir Charles A. Parsons in early experiments and turbine developments in England. Following a term in the Chilean Navy and engineering work in Peru, he became associated with the Westinghouse company in 1896 when George Westinghouse was introducing the Parsons turbine in this country. When the South Philadelphia works were established in 1916, Mr. Hodgkinson was chosen chief engineer and in 1926 was advanced to the office of consulting mechanical engineer for all branches of the Westinghouse company.

Dr. Luckiesh Honored by Optometry Foundation

For his contributions in "constructive ideas for optometric research" Doctor M. Luckiesh (Mem. '15) has been awarded a fellowship in the Distinguished Service Foundation of Optometry, Cleveland, Ohio. The Foundation contends that through his many papers and lectures presented before the Optometric Association, Doctor Luckiesh has promulgated the understanding by the optometric profession of the part lighting plays in the conservation of eyesight.

M. LUCKIESH

The Distinguished Service Foundation which was established in Boston, March 1927, has as its purpose effort "to provide an agency for encouraging research, inventive and experimental work by practising optometrists, physiologists, physicists, illuminating engineers and others, to award gold medals and fellowships for such research and scientific attainments, and to encourage and aid men and women of marked proficiency to discover knowledge which that will benefit human vision."

James W. Welsh, (Fel. '14) who in the fall of 1929 became identified with the Cleveland Railway Company as assistant to its president, has resigned to come to New York to establish his own organization of traffic consultants. After seven years as executive secretary of the American Electric Railway Association Mr. Welsh went to Cleveland a nationally recognized authority on electrical engineering and traffic problems, and a specialist in traffic engineering. He has devoted his time to studies of proposed coordination of rapid transit and surface lines, and the application of zone-fare principles to the Cleveland Railway system. By the president of that system he is accredited with having made possible the speeding up of surface lines and the realization of substantial operating economies. Mr. Welsh contends that the continued growth and development of our cities depends as much upon the efficient use of existing transportation facilities as upon the provision of additional ones; that we should be sure we are getting 100 per cent use from these facilities before assuming additional burdens. In 1924 he was a member of a special committee which studied European transporation conditions for the American operators of electric railways.

O. S. Peters (Assoc. '11) for many years conspicuous by his achievements as an inventor of electrical devices, has been made the recipient of the John Scott bronze medal for the invention of a telemeter for recording strains and pressures. The invention may be said to be the outgrowth of ten years' effort in technical research work with the Bureau of Standards. The instrument has been in commercial use for a number of years and has proved its value in an extended field of utility. Mr. Peters, after the completion of his technical studies at Montana State college, returned the following year as instructor in electrical engineering. His term of service with the Bureau of Standards was from 1910 to 1918, as assistant physicist.

A. W. Leonard, (Mem. '29) connected with Stone & Webster interests for the past 36 years, and president of the Puget Sound Power & Light Company, Seattle, retired from the presidency April 1 to assume the chairmanship of the board of directors of the parent organization, the Engineers Public Service Company, with offices in New York City. His predecessor in this capacity was Charles W. Kellogg, (Mem. '23), who has managed the Stone & Webster properties for an extended number of years, and who is now retiring after a most successful record.

B. A. Behrend (Fel. '12) of Wellesley Hills, Mass., has just had the honorary degree of doctor of engineering conferred upon him by the University of Darmstadt "for meritorious work in the construction of induction machines." Mr. Behrend has gained prominence in the American engineering world both by the assistance he has rendered the Institute in the past with his work on its committees and by his various other worthy engineering affiliations. He is at present carrying on a successful consulting engineering practise of his own at Wellesley Hills.

Donald M. Simmons (Fel. '28) chief consulting engineer of the General Cable Corporation, New York City, has been elected president of the Insulated Power Cable Engineers' Association. Other officers are T. F. Peterson, cable engineer of the American Steel & Wire Company, New York, vice-president, and R.J. Wiseman, (Fel. '27) chief engineer of the Okonite Company, Passaic, N. J., secretary and treasurer. The retiring officers are G. M. Haskell, president; W. A. DelMar, vice-president; and H. G. Burd, secretary and treasurer.

L. J. Bourke (Assoc. '23) for the past several years assistant to William H. McGrath (Mem. '20), vice-president of the Puget Sound Power & Light Company, Seattle, received appointment effective March 1, 1931, as manager of the company's southern district at Chehalis, Washington. Homer R. Chitty, Jr. (Assoc. '28), who has held office as manager of that district for some time past has been transferred to Tacoma in charge of the southwestern district of the company.

L. A. S. Wood (Mem. '24) manager of exterior lighting section, Westinghouse Electric & Manufacturing Company, Cleveland, Ohio, has been given complete charge of a new division centering all lighting activities of the company into a movement of coordination at the Cleveland works. This concentration represents the culmination of a nucleus plan made when the Westinghouse lighting activities first were established in Cleveland.

Clarence A. Mayo (Assoc. '13) electrical engineer of the Malden Eectric Company, Malden, Massachusetts, recently became assistant manager of the Eastern Massachusetts Electric Company. His headquarters will be in Salem. Mr. Mayo is a past chairman of the Electric Lines Club of New England and for two years chairman of the engineering section of the New England division of the N. E. L. A.

K. C. Christiansen (Mem. '21) for over ten years has been affiliated with the Electric Bond & Share Company and its subsidiary the Phoenix Utility Co.; now he has engaged with the Safe Harbor Water Power Corporation, Lexington Building, Baltimore, Md.

John Dibblee (Mem. '26) general superintendent of the Hydro-Electric Power Commission, the Niagara district, has been assigned to the recently created position of assistant to Henry C. Don Carlos (Fel. '18) the operating engineer of the provincial system.

John H. Muggli (Mem. '31) has been transferred from the Shell Oil Company's Martinez Refinery to the home office at San Francisco, where he will continue his capacity of electrical engineer.

Obituary

Robert J. Scott, (Fel. '13) professor emeritus of the University of New Zealand, Horomanga Island, Port Levy, Banks Peninsula, New Zealand, and for many years local honorary secretary of the Institute for New Zealand, passed away November 8, 1930.

He was born at Plymouth, England, September 14, 1861, the son of Rear Admiral Scott and a cousin of Captain Scott the South Polar explorer. He attended the Abbey School, Beckenham, King's College, London, and the Royal School of Mines, where his course included electrical engineering and management. Supplementing this by private tutelage in mechanical drawing and civil engineering under General H. Y. D. Scott, F. A. S., C. B., Director General of Works, England, thereafter he was employed under his father, Rear Admiral Scott, R. N., as superintendent of naval gun carriages at Woolwich Arsenal and at Chatham. In 1881, after extensive railway experience in England, he joined the New Zealand railway service, advancing from the position of locomotive draftsman to manager of the Addington works, designer for the locomotive department, and finally becoming acting locomotive superintendent. In 1888 he was appointed part time lecturer in engineering at Canterbury College, University of New Zealand; two years later he became lecturer in charge of engineering and then professor in charge. At the time of his retirement in February 1923, Professor Scott as the inventor and operator of many of its railway and transportational improvements was probably one of the most prominent figures in New Zealand's world of engineering. The School of Engineering is a lasting memorial to his foresight, initiative, and powers of organization, and, to quote, "it is fitting that the culmination of his work should be its recognition by the government as the national school of engineering of the Dominion." He joined the Institute as an Associate in 1902, advancing to the grade of Fellow in 1913. For an extended number of years he held chairs of engineering and electricity in the University of New Zealand. He was a member of the British Institution of Civil Engineers, serving on its advisory committee, and was also a member of the Institution of Mechanical Engineers.

Edward Dwight Priest, (Assoc. '12) for many years designing engineer in the railway department of the General Electric Company, died at his home in Schenectady March 26, 1931; he was 70 years of age. A native of Northfield, Massachusetts, and a graduate of Worcester Polytechnic Institute (1884), he was employed in 1887 by the Thomson Houston and General Electric Companies where his time was devoted chiefly to railway motor design, in charge of the work. One of his first achievements was the conception of a special-type railway motor light in weight for use on elevated lines. Railway electrification problems were his chief interest and here his contributions to development and improvement were of the greatest value. In 1888 he was the originator of the first box-frame motor ever marketed by his company; this was cast in one piece. In 1901 the electrification of the Manhattan elevated was one of a group of achievements under the leadership of Mr. Priest; as was also a special design of locomotive for the Boston & Ohio Railroad. When William B. Potter became railway department engineer of the General Electric Co. in 1895 he appointed Mr. Priest designing engineer in charge of railway motors, a position which he held until his retirement in 1926.

Beverly L. Worden, (Mem. '27), president of Cutler-Hammer, Inc., New York and Milwaukee, passed away at his home in West Orange, N. J. after an illness of several months. He was born in Chicago 61 years ago and received his B. S. in Civil Engineering from the University of Wisconsin in 1893. In 1901 he founded the Worden-Allen Company of Milwaukee, and in 1909 the Lackawanna Bridge Company of Buffalo; of both of these companies Mr. Worden was president, of the first until 1921, and of the latter until 1924, when he became general manager of the Newark Bay shipyard, Newark, New Jersey, building steel ships for the Emergency Fleet Corporation. For a period prior to the United States' entry into the war he was general manager also of the Submarine Boat Corporation. Early in 1923 Mr. Worden became identified with Cutler-Hammer, Inc., as its vice-president and director, later being chosen president. He was a representative member of several engineering organizations inclusive of The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the Western Society of Engineers. For the past number of years he had also been a member of the National Electrical Manufacturer's Association.

Nathan B. Ambler, superintendent of the hydroelectric plant, U. S. Engineering Department, Wilson Dam, Florence, Ala., and well-known as an electrical production engineer, died suddenly April 11 while driving his car in that city to which he had gone as a member of the staff of Hugh L. Cooper, of the Cooper Engineering Corp., consulting engineer for the construction of the Wilson Dam.

A native of Chatham, New York (1876), Mr. Ambler took a four years' course in the electrical engineering department of Columbia University, and for a while thereafter was employed as electrician of the Metropolitan Street Railway Company. This led to work with the Interurban Street Railway Company, which he served as substation foreman. Prior to his association with the Cooper Engineering Corporation, he was superintendent of a Niagara Falls power plant. His membership in the Institute dates from 1903.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institutue records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Collinot, Marcel A., 88 Sherman Ave., Newark, N. J.

Davis, R. H., Westinghouse E. & M. Co., East Pittsburgh, Pa.

DiLucci, A., Box 1051, Chicago, Ill.

Duane, George B., Otis Elevator Co., Yonkers, N. Y.

Gale, R. E., 706 N. 19th St., Boise, Idaho.

Kigar, D. F., 1403 Minnie St., Port Huron, Mich.

Muncy, V. E., Ohio Mechanics Institute, Cincinnati. Ohio.

Prehn, Victor N., 940 Broad St., Newark, N. J.

Van Wyck, P. V. R., Summit, N. J.

Local Meetings

Nebraska Sections Meet with Student Branches

The Nebraska sections of the A. S. M. E. and A. I. E. E. held their annual student meeting in Omaha on April 9, 1931, in cooperation with the Student Branches of both societies at the Universities of Nebraska and South Dakota.

Morning inspection trips included the 4th and Jones Streets plant of the Nebraska Power Company, or the Cudahy Packing Company plant. Afternoon trip opportunities included the Orpheum Theater air conditioning, or Ford Assembly Plant; WOW Broadcasting Station; Northwestern Bell Telephone Building; New Union Station, or Omaha Steel Works.

Dinner was held at the University Club, and during the student program, Phil Ehrenhard, chairman, University of Nebraska Branch, A. I. E. E., served as toastmaster. There was a brief address by Dean H. S. Evans, vice-president, District No. 6, A. I. E. E., and the following talks were given by students:

Human Nature in Engineering, by R. O. Rensch, senior, M. E., University of Nebraska.

Having a Hobby, by A. Steponaitis, chairman, University of South Dakota Branch, A. I. E. E.

Audible Light, by W. E. Stewart and S. M. Geis, seniors in E. E., University of Nebraska.

Several musical numbers were given by students of the University of Nebraska. There were 105 in attendance.

Boston Section Holds Student Meeting

Continuing a plan inaugurated in March 1930, the Boston Section and the student groups of Harvard University, Massachusetts Institute of Technology, Northeastern University, and Tufts College held a joint meeting at the Massachusetts Institute of Technology on the evening of March 26, 1931, with an attendance of 215. During a buffet supper, the students interested in specific fields of electrical engineering were seated at tables with engineers practising in that same field. Thus each student was given opportunity to receive information and advice regarding his favorite kind of electrical work.

M. B. Lambert, vice-president, Westhouse Electric & Manufacturing Company, gave an address on "The Engineer and His Outlook;" this proved to be very interesting to the students and the Section members. There was considerable discussion by both groups, and the meeting was considered one of the most successful of the year.

Toronto Section Holds Luncheon and Evening Meeting

In honor of President Lee and National Secretary Hutchinson, the Toronto Section held a luncheon at the Royal York Hotel, Toronto, March 27, 1931. Present were: D. A. McKenzie and G. D. Floyd, respectively chairman and secretary of the Section; C. E. Sisson and W. L. Amos, respectively vice-president and secretary of District No. 10; A. B. Cooper, director of the A. I. E. E.; I. M. Maclean, J. A. Magley, V. G. Smith, and W. F. Sutherland, members of the Section's executive committee; and T. R. Rosebrugh, F. A. Gaby, H. W. Price, W. A. Bucke, E. T. J. Brandon, W. F. Wright, A. H. Hull, F. R. Ewart, W. P. Dobson, S. E. M. Henderson, C. E. Schwenger, H. C. Don Carlos, M. B. Hastings, E. M. Wood, and F. F. Ambuhl, past chairmen of the Section.

In the evening, G. L. Lillie of the

Toronto Hydro-Electric System presented a paper "Factors in Design of 115/230-Volt Distribution in a Modern Residential District." President Lee addressed the meeting, and his description of problems he had encountered in development of water power sites in Quebec was especially interesting. National Secretary Hutchinson outlined the progress in Institute affairs, and emphasized the desire for constructive criticism and suggestions for the further development of ELECTRICAL ENGINEERING. The attendance was 91.

San Francisco Section Meets With Students

On March 27, 1931 the San Francisco Section held a meeting specially arranged to bring together the Section members and University of California, University of Santa Clara, Stanford University Student Branches. At a dinner preceding the program each student was seated with an engineer practising in the particular field in which the former was especially interested, thus offering excellent opportunities for helpful exchange of information and experiences.

The address of the evening was by R. R. Newell, professor of medicine and director of the department of radiology, at Stanford University Medical School, on the subject "The Use and Misuse of Electricity in Medicine," and was received with great interest. Dr. Newell exhibited many instruments used in making examinations.

Attendance at the dinner and at the address was 118 and 180, respectively.

Pittsfield and Schenectady Section Competition

Following the plan inaugurated last year to encourage their younger members to participate in programs, the Pittsfield and Schenectady Sections held joint meetings in Pittsfield March 17, 1931, and Schenectady April 3, 1931, for the presentation of papers by section members less than 30 years of age and who had not previously presented Institute papers. The programs were as follows:

Pittsfield

Operation of the Mercury Boiler Tube with High Thermal Stresses, by T. C. Ohart, Schenectady.

Pulps and Paper in the Electrical Industry, by M. B. Newell, Pittsfield.

A Method of Determining Power Transfer Limitations of Low-Voltage A-C. Networks, by R. G. Lorraine, Schenectady.

Network Transformers, by P. L. Christensen, Pittsfield.

Nontechnical Factors Affecting the Electrical Industry, by S. A. Holme, Schenectady.

Precise Frequency Determination, by C. W. Ransom, Pittsfield.

Schenectady

Noiseless Rotating Machinery, by S. J. Levine, Pittsfield.

The Polycyclic Thyratron Inverter, by R. S. Thurston, Schenectady.

Lightning Studies on Small High-Voltage Transformers, by M. F. Beavers, Pittsfield.

High-Voltage Impregnated-Paper Power Cables, by D. R. Carpenter, Schenectady.

A New Development in Iron-Core Reactors, by T. A. Wilson, Pittsfield.

Predetermination of Overvoltage in Electrical Systems Subsequent to Loss of Load, by J. W. Butler, Schenectady.

Prizes were awarded after consideration of the contents of the papers as well as the presentation. At the Pittsfield meeting, T. C. Ohart of Schenectady received the first prize, and S. A. Holme of Schenectady and C. W. Ransom of Pittsfield tied for second. The total numbers of points were Schenectady 496.3; Pittsfield 445. 85 attended the meeting, and 60 the dinner preceding it.

At the Schenectady meeting, J. W. Butler of Schenectady received the first prize, and T. A. Wilson of Pittsfield received second prize. The total numbers of points were, Schenectady 512.8; Pittsfield 486.4. 150 attended the meeting, and 90 the dinner preceding it.

Student Convention At Swarthmore College

The seventh annual local student convention sponsored by the Philadelphia Section was held at Swarthmore College on March 16, 1931, with seven schools participating: namely, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore. The program of the morning session was as follows:

Welcome—Dean Raymond Walters, Swarthmore College

An Automatic Timer for Races, by E. A. Speakman, Haverford College, 1931

Visual Testing Devices, by O. H. Schuck, University of Pennsylvania, 1931

Electrical Determination of Tensile Strength, by William MacNamee, Princeton University

Discussion of above papers.

The Bartol Laboratory, by Dr. T. H. Johnson, Franklin Institute

Those attending the convention were guests of Swarthmore College at luncheon, afterward separating into three groups, according to preference, to visit the Deepwater generating station of the American Gas & Electric and the United Gas Improvement Companies, the Lamokin substation of the Pennsylvania Railroad Company at Chester, Pa., or the General Electric Company switching equipment factory at Darby, Pa.

The latter part of the afternoon there was an inspection trip through the College buildings, followed by a dinner in the Whittier House.

The evening program included an organ recital, by Professor L. R. Shero of Swarthmore College, and the presentation of two papers:

Life of Henry, by R. M. Mitchell, Swarthmore College, 1931

Life of Faraday, by W. H. Radford, Drexel Institute, 1931

Three prizes were awarded for the presentation of student papers during the morning session, E. A. Speakman, receiving the first; O. H. Shuck, the second; and William MacNamee, third. Skits were presented by Drexel and Swarthmore students. The registration was 181.

Future Section Meetings

Cleveland

May 21, 1931—Annual dinner meeting. Speaker—W. S. Lee, president and consulting engineer, Duke Power Company, and president, American Institute of Electrical Engineers.

Detroit-Ann Arbor

May 19, 1931—Subject and speaker to be announced later.

June 20, 1931—Spring frolic.

Lehigh Valley

May 16, 1931—Annual meeting. Industrial Planning for the Future, by E. C. Stone, assistant to senior vice-president, The Philadelphia Company. Meeting to be held at Altamont Hotel, Hazleton, Pa.

Niagara Frontier

May 15, 1931—Subject and speaker to be announced later.

Seattle

May 19, 1931—The best paper submitted in the annual competition for prizes will be presented at this meeting.

Sharon

May 5, 1931—The Contributions of Telephone Research to the Talking Motion Picture Industry, by J. O. Perrine, Associate Editor, *Bell System Technical Journal.*

Spokane

May 22, 1931—Annual dinner meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

Toledo

May 22, 1931—Speakers—T. J. Nolan, Toledo Edison Co. and J. T. Greene, Police and Fire Alarm System.

June 12, 1931—Dinner and election of officers. Speaker—E. C. Stone, assistant to senior vice-president, The Philadelphia Company, and vice-president District No. 2, A. I. E. E.

Past Section Meetings

Akron

The Development of Electrical Engineering Since the Invention of the Incandescent Lamp, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 25. Attendance 350.

Inspection trip through the Hoover Suction Sweeper plant at North Canton. After dinner, M. L. Pierce gave a talk on Engineering in Selling. April 9. Attendance 80.

Atlanta

The Lighting of the Future, by A. L. Powell, Director, Edison Lighting Institute. Illustrated. Joint meeting with the A. S. M. E. Section. Dinner preceded the meeting. March 23. Attendance 80.

Baltimore

Artificial Lightning, by D. R. Rowland. After the speaker described the new d-c., high-voltage equipment installed at the Locke Insulator Company, those at the meeting adjourned to the laboratory of that company where a demonstration of the one and one-half million volt a-c. equipment and the two and one-half million volt d-c. equipment was given. March 20. Attendance 105.

Cleveland

Industrial Applications of Vacuum Tubes and Photoelectric Tubes, by E. L. Manning, General Electric Company. Illustrated and demonstrated with actual equipment. March 19. Attendance 210.

Connecticut

The Sun Lamp, by Paul Luckenbach, General Electric Co. Illustrated with slides. Meeting held at the Bridgeport Works of the General Electric Co. March 25. Attendance 40.

Dallas

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engineering Corp. March 5. Attendance 98.

Engineer's Responsibility, by Dean F. C. Bolton, Texas A. & M. College. Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E., gave a talk on Institute activities. March 25. Attendance 74.

Denver

Engineering Considerations in the Design of Open Wire Line for Communication, by G. S. Dring, American Tel. & Tel. Co. Illustrated. Dinner preceded the meeting. March 13. Attendance 52.

Dinner and card party. March 20. Attendance 72.

Detroit-Ann Arbor

The Sound of a Shadow, by John B. Taylor, General Electric Co. Joint meeting with the Institute of Radio Engineers. March 17. Attendance 650.

"The United States Should Own and Operate Muscle Shoals" was the subject of a debate presented by students of the Stump Speakers Society from the University of Michigan and Detroit Institute of Technology. The judges decided in favor of the negative, which was supported by the team from the University of Michigan. Joint meeting with the Illuminating Engineering Society, sponsored by the educational committee of the Associated Technical Societies of Detroit. March 24. Attendance 100.

Erie

So-Called Network in A-C. Distribution, by P. F. Pugh, General Electric Co.;

Latest Methods in Mechanical Balancing, by F. M. Kirkpatrick, General Electric Co.;

Load Control, by O. E. Lang, Pennsylvania Electric Co. Members of the Technical Federation of Erie invited. February 17. Attendance 105.

Historical Developments in Electrical Engineering During the Past Fifty Years and the Influence of Same Upon Modern Life and Civilization, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 23. Attendance 120.

Fort Wayne

The D-C. Saturable Reactor, by B. A. Case, General Electric Co.;

The Theory of Probability, by W. J. Morrill and E. J. Schaefer both of the General Electric Co. March 12. Attendance 60.

Houston

Recent Developments in High Speed Relaying, Stability, and Lightning Protection on Transmission Systems, by I. T. Monseth, Westinghouse Elec. & Mfg. Co. February 26. Attendance 59.

Speed, Progress, and Unemployment, by Dr. William McClellan, vice-president, Stone & Webster Engineering Corp. March 3. Attendance 26.

The Professional Engineer, by Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E. March 23. Attendance 23.

Indianapolis-Lafayette

The Cathode Ray Oscillograph and Its Application to the Recording of Natural Lightning, by Professor R. H. George, Purdue University. Illustrated with slides. Joint meeting with the A. S. M. E. Section. April 3. Attendance 70.

Kansas City

Preservation Treatment of Pine Poles, by R. T. Blair, International Creosoting Co. Moving pictures followed. February 24. Attendance 50.

The Missouri River as a Factor in World Trade, by Frank V. Smith, General Electric Co. Film—"The All-Electric Ship California." Joint meeting of all the Engineering Societies in Kansas City. March 6. Attendance 350.

Lehigh Valley

Adventures in Science, by Oliver Ajer, General Electric Co. Demonstrated. Dinner preceded the meeting at the Hotel Sterling, Wilkes-Barre. March 27. Attendance 300.

Los Angeles

Annual joint meeting with the Student Branches of the University of Southern California and the California Institute of Technology, at which the following papers were presented by Students:

The Application of Engineering to the Development of Automobile

LIGHTING, by Walter Weiss, University of Southern California;

WAVE-FORM OF CURRENT IN CONVERTERS, by Adin Mathews and Louis Hendrixson, University of Southern California;

THYRATRON THEORY, by G. W. Read, California Institute of Technology;

DISCHARGE IN HIGH VACUUM, by E. O. Erickson, California Institute of Technology;

THE VACUUM SWITCH, by Charles Lash, California Institute of Technology. At the conclusion of the technical session, the Aeronautics Laboratory, Astro-physics Machine Shop, and Electrical laboratories were inspected. March 10. Attendance 300.

Louisville

THE DEVELOPMENT OF LOUISVILLE, by E. A. Erskine, Southern Bell Telephone & Telegraph Co. March 20. Attendance 30.

Madison

SOME FACTORS AFFECTING NOISE IN TELEPHONE CIRCUITS ARISING IN INDUCTIVE EXPOSURES, by W. C. Lallier, Wisconsin Telephone Co. March 11. Attendance 135.

Memphis

SOME ASPECTS OF THE SCIENTIFIC WORK OF THOMAS JEFFERSON, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. March 25. Attendance 61.

Milwaukee

BUILDING PROSPERITY AVENUE, by H. H. Magdsick, General Electric Co. Illustrated. Joint meeting with the Engineers Society of Milwaukee. March 18. Attendance 275.

THE NEW PHYSICS, by Professor Warren Weaver, University of Wisconsin. April 1. Attendance 93.

Minnesota

ORIENTAL TRAVELOGUE, by C. P. Sigerfoos, Professor of Zoology. March 30. Attendance 45.

Niagara Frontier

THE PROGRESS OF ELECTRICAL ENGINEERING DURING THE LAST FIFTY YEARS, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. Illustrated with slides. March 20. Attendance 125.

North Carolina

Annual spring meeting. Professor W. S. Rodman, vice-president, District No. 4, A. I. E. E. discussed Institute activities. The following papers were presented, all of which were illustrated with slides:

TELEPHONE FACILITIES USED BY POWER COMPANIES, by O. J. Huie, Southern Bell Telephone & Telegraph Co., and Blair Jenkins, Jr., Carolina Power & Light Co.;

OIL CIRCUIT BREAKER DEVELOPMENTS, by R. M. Spurck, General Electric Company;

INSULATION VALUE OF WOOD POLE LINES FOR LIGHTNING PROTECTION, by J. A. Jones, Carolina Power & Light Co. After dinner, Dr. C. L. Fortescue, Westinghouse Electric & Mfg. Co., gave a talk entitled INFLUENCE OF RECENT LIGHTNING INVESTIGATIONS AND STUDIES ON PRACTICAL DESIGN AND OPERATION OF HIGH VOLTAGE TRANSMISSION SYSTEMS. March 10. Attendance 120.

Oklahoma City

SPEED, UNEMPLOYMENT, AND PROGRESS, by Dr. William McClellan, vice-president, Stone & Webster Engg. Corp. March 6. Attendance 102.

Rochester

APPLICATIONS OF THE LIGHT SENSITIVE TUBE TO INDUSTRY, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. March 5. Attendance 201.

St. Louis

DEVELOPMENT OF THE MODERN WATT-HOUR METERS, by Fred Holtz, Sangamo Electric Co. Illustrated with slides. March 18. Attendance 70.

San Antonio

THE PROFESSIONAL SOCIETY, by Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E. Following this lecture several motion pictures were shown. March 24. Attendance 78.

San Francisco

INDUSTRIAL APPLICATION OF ELECTRICITY, by Louis F. Leurey, consulting electrical engineer. The meeting was preceded by dinner at the Engineer's Club. February 27. Attendance 70.

Saskatchewan

RECENT DEVELOPMENTS OF DIRECTIONAL FLYING, by W. L. Laurie, Department of Civil Aviation at Ottawa. Illustrated. February 6. Attendance 29.

Schenectady

HISTORICAL DEVELOPMENTS IN ELECTRICAL ENGINEERING IN THE PAST FIFTY YEARS, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 27. Attendance 250.

Seattle

J. E. Hawe, Great Northern Railway, presented a paper on the result of two years' operation of the Great Northern Railway Electrification. Film—"Wildwood Coal Mines, 100 Per Cent Electrified." February 17. Attendance 81.

Spokane

RECENT DEVELOPMENTS IN ELECTRICAL ENGINEERING, by L. W. W. Morrow, editor, *Electrical World*. Dinner in honor of the speaker preceded the meeting. March 10. Attendance 27.

Syracuse

RECENT RESEARCH DEVELOPMENTS, by J. M. Stedman, Westinghouse Electric & Mfg. Co. February 23. Attendance 167.

AUDIBLE LIGHT, by John B. Taylor, General Electric Co. March 9. Attendance 580.

Toledo

VACUUM TUBES AND PHOTOELECTRIC CELLS IN INDUSTRY, by E. L. Manning, General Electric Co. March 20. Attendance 800.

Toronto

STANDARDIZATION, by B. Stuart McKenzie, Canadian Electrical Standards Association. March 13. Attendance 50.

DEPENDENCE OF FUTURE RESEARCH IN THE APPLIED SCIENCES UPON THE DEVELOPMENT AND REFINEMENT OF MARKETING, by W. W. Goforth, Cockfield Brown & Company. Illustrated. April 10. Attendance 41.

Urbana

INDUCTIVE INTERFERENCE IN TELEPHONE CIRCUITS, by W. W. Russell, Illinois Bell Telephone Co. March 11. Attendance 175.

Utah

The following five minute talks were presented by members of the Section:

THE MERCURY TURBINE, by C. B. Shipp, General Electric Co.;

CONTACTOR CONTROL, by V. J. Del Duke, Utah Copper Co.;

ELECTRICAL LABORATORY EQUIPMENT, by J. H. Hamilton, University of Utah;

INSULATING VARNISHES, by J. A. McDonald, General Electric Co.;

THE OVERHUNG TURBINE, by B. E. Jordon, Utah Power & Light Co.;

THE SYNCHRONOUS MOTOR, by R. W. McNeil, Westinghouse Elec. & Mfg. Co. Film—"The Electric Ship." March 16. Attendance 42.

Worcester

SECONDARY NETWORKS OF PRESENT DAY, by D. F. Blake, General Electric Co. March 18. Attendance 45.

Past Branch Meetings

Alabama Polytechnic Institute

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. Professor Rodman also gave a brief history of the Institute. March 19. Attendance 68.

University of Alabama

Turbines, by Professor John M. Gallalee. Film—"Steam Turbines." March 9. Attendance 30.

University of Arkansas

Three films shown: "Dynamic America," "Steam Turbine with a Solid Rotor," and "Body and Soul." March 13. Attendance 53.

Armour Institute of Technology

Michael Faraday, by T. A. McGill, student;

Joseph Henry, by M. J. Schinke, student. March 20. Attendance 40.

University of British Columbia

Carrier Current in Telephony, by H. Van Allen, student. March 17. Attendance 14.

Polytechnic Institute of Brooklyn

A New Method of Scanning for Television, by Ivan Bloch, student;

Mercury Arc Rectification, by William Powers, student;

Breaking the A-C. Arc in Circuit Breakers, by Leonard Evans, student. Ivan Bloch received first prize and William Powers second prize. March 9. Attendance 26.

Bucknell University

Life and Works of Joseph Henry, American Physicist, by Percy Hort, Branch secretary. Film—"Steam Turbine with a Solid Rotor." March 9. Attendance 9.

Talks on the life and work of Archimedes, Galileo, and Sir Isaac Newton, by William Griffith, student. March 30. Attendance 8.

California Institute of Technology

Joint meeting with the Los Angeles Section and the University of Southern California Branch at which six papers were presented by students. (See report under Past Section Meetings).

University of California

Two films shown as follows: "Atomic Hydrogen Welding," and "Straight-Line Production of Induction Motors." Joint meeting with the A. S. M. E. March 11. Attendance 75.

Inspection trip to the Newark substation of the Pacific Gas & Electric Co. March 21. Attendance 31.

Modern Practise in Steam-Plant Design, by R. C. Powell, Pacific Gas & Electric Co. March 25. Attendance 50.

University of Cincinnati

High-Tension Cable and Dielectrics, by Mr. Calvert, General Electric Co. March 4. Attendance 41.

Clarkson College of Technology

Discussion of Branch activities. March 3. Attendance 21.

Colorado State Agricultural College

The Life and Experiments of Michael Faraday, by Oscar Baer, student. March 9. Attendance 9.

Film—"Dynamic America." March 16. Attendance 12.

Annual Engineers' Day held jointly with the A. S. M. E. Branch. The Influence of Gold and Silver Production on Economic Conditions, by Frank E. Shepard, Supt. U. S. Mint in Denver. March 28. Attendance 150.

Cooper Union

Magnetic Shielding of Straight D-C. Conductors, by George C. Neuschaefer and August B. Mundel, students. March 18. Attendance 12.

Cornell University

Two films shown as follows: "The Steam Turbine," and "Dynamic America." March 25. Attendance 23.

University of Detroit

Five moving pictures shown. Talks by Dean R. E. Lawrence, A. W. Mitchell, Chrysler Motor Co., and Professor F. Lysenmeyer. March 19. Attendance 210.

Harvard University

Inspection trip to the General Electric Co. at Lynn, Mass. Match 16. Attendance 25.

Iowa State College

Smoker. April 18. Attendance 140.

State University of Iowa

Film—"Conowingo." February 11. Attendance 40.

Worlds Water Power and the Hoover Dam, by W. B. Knight, student. February 18. Attendance 29.

Development of Television in the United States, by Mr. Kosek, student;

Production of Power from the Tropic Seas, by F. O. Lyddon, student. February 25. Attendance 37.

Rectifiers, by Mr. Ten Eyck, student. Film—"Dynamic America." March 4. Attendance 39.

The Mercury Vapor Turbine, by Mr. Lewis, student;

Later Applications of the Electricity in Transportation, by R. Marchant, student;

Electrical Developments in the Far East, by T. S. Mariano, student. March 11. Attendance 26.

The Cathode Ray Oscillograph, by Mr. Wilkins, student. Film—"Steam Turbine with a Solid Rotor." March 25. Attendance 39.

Kansas State College

Patents and Inventions, by Professor R. G. Kloeffler, counselor. (Afternoon session). February 18. Attendance 70.

The program of the evening session was the same as that of the afternoon session. February 18. Attendance 30.

Talk by E. D. Bell, United Power & Light Corp. (Afternoon session). March 5. Attendance 75.

The program of the evening session was the same as that of the afternoon session. March 5. Attendance 35.

Lehigh University

Psychology of Illumination, by J. B. Sponsler, student;

The Engineer in College and Out, by A. J. Standing, Bethlehem Steel Co. February 18. Attendance 43.

Audible Light, by John B. Taylor, General Electric Co. February 23. Attendance 250.

Talking Movies, by D. C. McGalliard, Electrical Research Products, Inc. March 4. Attendance 250.

Three films were shown: "Steam Turbine with a Solid Rotor," "Mechanized Mine of the Butler Coal Company," and "Dynamic America." March 20. Attendance 154.

Marquette University

Executive Board meeting. March 3. Attendance 8.

Inductance, by Mr. Forman, Louis Allis Manufacturing Co. Election of officers as follows: Ellsworth Ziehm, chairman; Anthony Cain, vice-chairman; Donald Boehmer, Secretary; Robert Manion, treasurer. March 5. Attendance 27.

Massachusetts Institute of Technology

Super-Power Production, by Francis D. Weeks, student;

Power Factor Correction and the Fynn-Weichsel Motor, by Gordon S. Brown and John C. Gibson, students. March 17. Attendance 57.

Inspection trip to the Woburn Station of the Edison Electric Illuminating Co. of Boston, and the Tewksbury substation of the New England Power Association. April 1. Attendance 17.

Michigan College of Mining and Technology

Electric Lighting, by Paul Junttila, student;

Gerald Warrener, Ontanogan Power Project, outlined in detail the routine to be followed in putting up a transmission line. March 11. Attendance 26.

Michigan State College

The Change-Over from 30 to 60 Cycles in Grand Rapids, Michigan, by H. L. Abrahamse, student;

Summer Experiences with the General Electric Company, by R. B. McCall and L. Switzgable, students. March 10. Attendance 23.

University of Michigan

Three students outlined their experiences during summer employment. March 4. Attendance 30.

Mississippi A. & M. College

Finances of American Utilities and Some Peculiar Uses of Electricity, by W. P. Gearhiser, student;

Supernatural Power, Inc., by P. W. Godard, student. March 13. Attendance 24.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. March 24. Attendance 31.

Missouri School of Mines and Metallurgy

J. D. Roy, student, outlined student courses given by the Westinghouse Elec. & Mfg. Co. March 11. Attendance 18.

St. Pat's Electrical Show. March 21. Attendance 437.

Engineering Achievements of 1930, by J. E. Stokes and J. D. Shelton, students. Professor I. H. Lovett, counselor, gave a talk on the construction of Bagnell Dam. April 1. Attendance 20.

Montana State College

Cut-Out Designs for Street-Lighting Circuits, taken from *General Electric Review*, presented by Wesley C. Funk, student;

Electric Power in the Lumber Industry, by Jean Smith, student;

Treating Poles, taken from *Western Electric News*, presented by Carl Wall, student. Film—"Arc Welding." March 19. Attendance 151.

University of Nebraska

R. A. Richardson, Program Service Company, outlined problems encountered with the telephone radio and gave solutions to many of these problems. March 11. Attendance 39.

University of Nevada

Modern Radio Stations and Transmitting Equipment, by Mr. Knapp, student. February 25. Attendance 11.

Geophysical Prospecting, by Professor Clark Amens. March 4. Attendance 19.

Electric Power in Connection with the Lumber Industry, by Chester Elliott, student;

New Developments in Photoelectric Cells, by E. H. Tucker, student. March 11. Attendance 12.

Film—"The Single Ridge." March 18. Attendance 23.

Newark College of Engineering

Joint meeting with Rutgers University Branch. Inspection trip through Newark College of Engineering Laboratories. Address of Welcome by President A. R. Cullimore, Newark College of Engineering. Short address by Dean P. H. Daggett, Rutgers University. Mr. Whitmore, Fox Film Corp., presented a talk on Making Movietone Pictures. March 9. Attendance 66.

University of New Hampshire

Advantages and Disadvantages of A. I. E. E., by F. Perkins, student;

Suggestions for Improvement of A. I. E. E., by J. Carlen, student;

Membership in A. I. E. E., by R. Williams, student. March 7. Attendance 33.

Election of officers as follows: P. A. Rolfe, chairman; R. H. Williams, Secretary. Film—"Blasting the Water Highways of America." April 1. Attendance 31.

University of New Mexico

The Life of Michael Faraday, by C. E. Henderson, Branch chairman. Election of officers as follows: M. Austin True, chairman; E. W. Huffman, vice-chairman; Stanley O. Fish, secretary-treasurer. April 2. Attendance 11.

College of the City of New York

Film—"Steam Turbine with a Solid Rotor." March 12. Attendance 35.

New York University

Power-Factor Correction, by L. F. Anderson, student;

Operation and Application of the Cathode Ray Oscillograph, by A. E. Bell, student;

Acoustics of Auditoriums, by M. Bogstahl, student. February 16. Attendance 18.

Business meeting. March 2. Attendance 18.

Cooperative Courses, by G. J. Helis, student;

The Mercury Arc Rectifier, by O. M. Lerz, student. March 16. Attendance 17.

Color in the Talkies, by C. Papini, student;

New York City West Side Development, by J. B. McNally, student;

History of Petroleum, by S. Podowitz, student;

Foreign Jobs, by G. J. McGillivray, student. March 30. Attendance 18.

North Carolina State College

Life of Joseph Henry, by L. C. Hubbard, student. March 31. Attendance 34.

North Dakota State College

Engineering and Education, by R. V. Wright, president, American Society of Mechanical Engineers. Joint meeting with the A. S. M. E. Branch. March 30. Attendance 55.

Film—"The Single Ridge." April 1. Attendance 60.

University of North Dakota

Informal talk by Professor D. R. Jenkins. April 1. Attendance 11.

Northeastern University

Traffic Control, by O. M. Jacobi, Submarine Signal Corp. Joint meeting with A. S. M. E. Branch. February 24. Attendance 50.

University of Notre Dame

Transatlantic Telephone Communication, by A. M. Rose, American Tel. & Tel. Co. Patrick Murray, student, presented a review of engineering new items. Joint meeting with the Notre Dame Engineers' Club. March 16. Attendance 187.

Ohio Northern University

Galileo's Life, by Mr. Jacobs, student. April 2. Attendance 14.

Ohio University

What Constitutes an Education?, by E. W. Chubb, Dean of the College of Liberal Arts. Report of the Middle Eastern District Meeting given by Harold Swagart, student. April 1. Attendance 19.

Oklahoma A. & M. College

Rural Electrification, by Don Heffiner, student. February 26. Attendance 26.

History of the Electrical Industry and George Westinghouse's Developments, by Mr. Hammond, Westinghouse Elec. & Mfg. Co. March 12. Attendance 41.

A film was presented showing the developments in the oil industry in Oklahoma. Joint meeting with the A. S. M. E., A. S. C. E., and Chemical Engineers. March 26. Attendance 150.

Under Water Cables, by Paul Warren, student. April 9. Attendance 15.

University of Oklahoma

The Life of Michael Faraday, by Roy J. Thompson, student. February 19. Attendance 33.

Maintenance of High-Voltage Lines While in Operation, by Mr. Steele, Oklahoma Gas & Electric Co.;

The Hoover Dam, by Charles Ludwick, student. March 26. Attendance 35.

Oregon State College

A Biography of Michael Faraday, by Elliott MacCracken, student;

Joseph Henry, by Alton Everest, student. March 31. Attendance 39.

Long Distance Telephone Circuit Facilities, by A. K. Morehouse, Pacific Tel. & Tel. Co. April 7. Attendance 42.

Pennsylvania State College

Film—"Atomic Hydrogen Welding." January 13. Attendance 132.

Inspection trip. April 11. Attendance 72.

University of Pennsylvania

Discussion of Branch activities. March 5. Attendance 20.

Talk by Professor C. D. Fawcett, counselor. Election of officers as follows: C. N. Maxfield, chairman; W. S. Caldwell, vice-chairman; H. D. Sarkis, secretary; W. H. Young, treasurer. March 23. Attendance 24.

Pratt Institute

Fourth Annual Convention held jointly with the A. S. M. E. and the Wohler Chemical Society. In the afternoon, three papers were presented by students, as follows:

History of Chromium, by L. K. Teubner;

Manufacture of Mazda Lamps, by S. P. Terni;

Principles of Operation of the Linotype, by N. W. Mackenzie.

In the evening the following talks were presented:

Brief addresses, by Dr. S. S. Edmands, Director School of Science & Technology, Ernest Hartford, assistant secy., A. S. M. E., and H. H. Henline, assistant national secy., A. I. E. E.

Our Nation's Health, by Ralph O. Clock, Davis & Geck Co.;

Television, by P. B. Smith, New York Telephone Co. March 25. Attendance 300.

Rensselaer Polytechnic Institute

Stability of Interconnected Systems, by W. E. Mayott, student. Illustrated. March 10. Attendance 150.

How Telephone Communication Serves Modern Business, by B. K. Rhodes, New York Telephone Co. Films—"The Telephone Family," and "The Flying Telephone." The following officers were elected: J. J. Lewis, chairman; F. S. Claassen, vice-chairman; H. A. Schlieder, secretary-treasurer. April 7. Attendance 180.

Rhode Island State College

The Nature of an Engineer's Work with a Public Utility, by D. Daly and J. Knapp, Blackstone Valley Light and Power Association. March 12. Attendance 22.

Business meeting. March 26. Attendance 13.

University of South Carolina

The Hoover Dam, by Charles O. Warren, student;

To Europe Via the North Pole, by J. J. Duffie, student. March 16. Attendance 29.

South Dakota School of Mines

Film—"Steam Turbines." March 10. Attendance 95.

Almon Bjerke elected chairman for next term. March 20. Attendance 32.

University of Southern California

Joint meeting with the Los Angeles Section and the California Institute of Technology Branch, at which six papers were presented by students. (See report under Past Section meetings.)

Southern Methodist University

Electronic Theory and Its Application, by Robert M. Kennedy, Southwestern Bell Telephone Co. Talk and demonstration of a 3.5 meter radio receiver and transmitter by D. J. Tucker, student. F. H. Gable, Branch Chairman, described the new radio station at the university. January 21. Attendance 36.

Description of the new 7½-watt amateur radio station W5 QG of S. M. U., operating on 20 meters, by F. H. Gable, Branch chairman. March 18. Attendance 20.

Stevens Institute of Technology

The Accurate Comparison of Frequencies by Means of the Low-Voltage Cathode Ray Tube, by F. L. Fuller, Branch secretary. March 17. Attendance 20.

Syracuse University

The Life of Faraday, by George Cowell, student;

The Life of Henry, by Paul Greiner, student. March 13. Attendance 24.

The Engineer Five Years After Graduation, by Mr. Pratt, The Niagara & Hudson Power Co. April 10. Attendance 26.

University of Tennessee

Electricity, Past, Present and Future, by C. M. Ripley, General Electric Co. March 12. Attendance 133.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, vice-president, District No. 4, A. I. E. E. March 27. Attendance 25.

University of Texas

The Overhead Distribution System of the Austin Power Plant, by J. H. Dunaway, student. February 26. Attendance 14.

The North Austin Substation, by H. J. Adams, student;

The East Austin Substation, by J. H. Neidert, student. March 12. Attendance 11.

University of Vermont

Hollow-Spun Concrete Poles, by M. Ciardelli, student;

Measurement of Frequency of Radio Transmitters, by J. J. Hay, student. March 10. Attendance 23.

Short business meeting. Life and Work of Michael Faraday, by E. S. Judkins, student;

Life of Henry, by E. E. Whitney, student;

A description of Faraday's generator was given by Professor R. O. Buchanan. March 24. Attendance 21.

Virginia Military Institute

Film—"Assembly of Ford Cars." March 19. Attendance 49.

Three films were shown: "The Busy Body," "Carboloy," and "The Wings of the Army." April 2. Attendance 50.

Virginia Polytechnic Institute

Films—"Steam Turbine with a Solid Rotor," and "Dynamic America." April 9. Attendance 255.

University of Washington

Film—"Nature's Frozen Credits." February 5. Attendance 34.

The Centralia Power Project, by B. T. Travis, City Light and Fixture Co. February 19. Attendance 26.

The Impulse Generator, by Herbert N. Steen, student. February 26. Attendance 10.

Life of Michael Faraday, by James A. White, student. April 2. Attendance 8.

Washington State College

Business meeting. February 10. Attendance 20.

Cushman Power Project, by Mr. Backemole, student. March 5. Attendance 23.

Films—"King of the Rails" and "The Cascade Tunnel." March 12. Attendance 43.

Washington University

Business meeting. April 2. Attendance 14.

West Virginia University

The following talks were presented by students:

Propagation of Radio Waves, by A. W. Friend;

Building a Substation, by F. E. Watson;

Use of Paper in Electrical Apparatus, by W. N. Engle;

Electric Control Permits Two Elevators in One Shaft, by E. D. Harris;

Construction of the Radio Vacuum Tube, by W. P. McCue;

$28,000,000 Rock Island Hydroelectric Development, by G. H. LeFevre. March 3. Attendance 32.

The following talks were presented by students:

Reducing Transformer Failures Due to Lightning, by C. J. McCormick;

Electrification of the C. M. & St. Paul Railway, by C. F. Stewart;

Power Distribution in Belgium, by K. D. Moss;

Use of Instrument Transformers, by P. Staff;

Effect of Temperature on Properties of Steel, by T. E. Palmer;

Modern Methods of Emptying Grain Cars, by J. N. Simpson. March 10. Attendance 31.

The following talks were presented by students:

[illegible]tors, by C. E. Higgins;

Gas Electric Bus, by C. B. Withers;

Grain Cars Unloaded in Six Minutes, by P. N. Vanney;

Two Elevators in One Shaft, by D. C. Kennedy;

Hydrogen Cooling for Large Generators, by W. C. McMillion;

D-C. Transmission, by H. E. Kerwin. March 17. Attendance 33.

The following talks were presented by students:

Method of Cleaning Coal Gas, by H. A. Lewis;

Electrical Advertising, by R. W. Blair;

Electrically-Heated Garden Plot, by M. L. Sprigg;

Westinghouse Commercial Test Course, by E. D. Harris;

Diesel Electric Locomotive, by C. J. O'Leary. March 24. Attendance 32.

University of Wisconsin

Three films shown as follows: "Building New York's Newest Subway," "Driving the Cascade Tunnel," and "Hydroelectric Power Production." March 25. Attendance 95.

Worcester Polytechnic Institute

Inspection trip through the New England Telephone & Telegraph Company. March 9. Attendance 40.

University of Wyoming

Business meeting. March 3. Attendance 12.

Yale University

The Muscle Shoals Project, by J. N. Buckwalter, student;

Effect of Lightning Voltages on Rotating Machinery, by D. B. Fisk, student;

The Electron Tube and Its Application to Industry, by R. C. Schlitt, student. March 12. Attendance 13.

During the week of March 25th to April 2nd, the engineering seniors went on the annual inspection trip. Attendance 90.

Public Speaking, by Professor Hubert Greaves. Illustrated. April 9. Attendance 29.

Employment Notes

Of the Engineering Societies Employment Service

Men

Available

GRADUATE of five-year cooperative school in electrical engineering; speaks Spanish and English fluently; one year study of production methods and five years' of street railway experience. Desires position in any state or nation. Location, immaterial. Age 24. C-9002.

COLLEGE GRADUATE class of 29. B. S degree in electrical engineering. 25, single. General Electric Test, general engineering and business courses. Interested in position in engineering department of manufacturing or utility company. Available at once. Location, eastern states. C-9003.

1928 GRADUATE ELECTRICAL ENGINEER, 26, married. One year G. E. Test; one year transformer engineering design, six months' railway signaling. Desires position with railway, power, or manufacturing company. Available on short notice. Location, immaterial. C-[illegible].

GRADUATE ELECTRICAL ENGINEER, 35, experienced large prominent electrical manufacturer, test course, sales and engineering departments, quotation, design, research, dedevelopment, factory engineering supervision, technical reports. Investigation materials, power-factor correction problems and distribution systems. Transformers, motors, generators, switchboards, etc. Desires position, design, sales, consulting, engineering, general technician. Location preferred, east, south. C-7321.

1929 GRADUATE ELECTRICAL ENGINEER, age 24; 15 months of General Electric Test course and first year of advanced engineering course. Now taking graduate work at Harvard Engineering school. Desires position with a future. Location preferred, Cleveland, Ohio. Available in June. C-8979.

ELECTRICAL ENGINEER, E. E. degree, 26, single. General Electric Test course, public utility test experience. Two years' experience sound picture industry. Interested in position with manufacturing company or public utility. Available at once. C-4810.

ELECTRICAL ENGINEER, 30, single, technical graduate, G. E. Test, 10 years design and construction of substations, power plants, electrical railways and mines, 5 years foreign. Desires position as engineer or general foreman. Location, anywhere. Available at once. C-217.

GRADUATE ELECTRICAL ENGINEER, 28, four years' manufacturing experience in production and engineering on electrical motors. Desires position with company where greater opportunities are offered. C-2882.

GRADUATE ELECTRICAL ENGINEER, 35, good technical school. Ten years' experience in electrical station construction and design drafting, including considerable mechanical experience. Latest position superintendent of design and construction of transformer substation. Prefers station design and construction with utility, would consider engineering industrial plant maintenance or operation. C-7043.

GRADUATE ELECTRICAL ENGINEER, 25. Three years electrical test engineer, public utility company. One and one-half years electrical design engineer resistor control devices. Desires electrical engineering position with definite future opportunities. Prefers development and design of signal apparatus. Available immediately. Location preferred, Metropolitan New York, but will consider others. C-8999.

ELECTRICAL ENGINEER, age 28; single, considerable industrial experience; one year as graduate assistant; M. S., Iowa State College, 1930; B. S., Pennsylvania State College, 1925. Desires position as instructor, with the prospect of a permanent teaching position. C-3202.

ELECTRICAL ENGINEER, university graduate, 36, married. Background of eight years' experience electrical testing in field and laboratory. Additional 3½ years' experience in testing and manufacture of radio tubes. Desires position as test engineer with radio tube manufacturer. Location preferred, Metropolitan New York. Available now. B-8817.

ENGINEER, E. E. 1926 Ga. Tech. Age 29, married. Several months drafting with Georgia Power Company. Five years' experience in large sugar mill in Cuba. Four years as chief electrician. Working knowledge of Spanish. C-9027.

1931 ELECTRICAL GRADUATE, single, 23, available immediately. Will receive diploma from Texas University in June. Desires any engineering work with opportunity to advance. Has had experience in bookkeeping and typing. C-9019.

ELECTRICAL AND ILLUMINATING ENGINEER, B. S. and E. E. degree, 31, married. Two years' experience with incandescent lamps. Two years designing motor controllers and pilot switches for large machine tools. Seven years' experience with designing motor starters, speed regulators, resistance specialities, theater dimmers, flood-lighting and window lighting control. Location preferred, New York or California. B-4850.

ELECTRICAL ENGINEER, recent graduate, desires a position in the East with an electrical contractor or with a manufacturing concern for production. C-8975.

GRADUATE ELECTRICAL ENGINEER, single, two years' experience on factory apprenticeship course, electrical and mechanical testing, five years sales engineer in wire and cable industry, four years industrial selling. Desires position as sales engineer or commercial and power sales work with a utility. Location preferred, Eastern United States. B-6002.

COLLEGE GRADUATE, 23, single, B. S. in E. E. in 1929. Eighteen months' experience with service department public utility. Desires position in any electrical line with future and opportunity for advancement. References. Available at once. C-9034.

GRADUATE ELECTRICAL ENGINEER, Columbia University, 1906. Age 45. Twenty-five years' experience with design and general engineering problems of steam-electric generating stations and distribution substations. Desires position as electrical engineer with public utility company or engineering firm. A-5466.

DEVELOPMENT AND RESEARCH ENGINEER, M. E., E. E. with considerable experience and successful record with intricate electromechanical problems involving theory and mathematics, high designing and supervising skill. Radio-frequency circuits and measuring instruments. Remote control and public-address systems. Position desired in New York City. A-165.

SENIOR ELECTRICAL ENGINEERING STUDENT, 23, wishes appropriate opening in electrical industry; manufacturing, test or operating. Best references. Location, immaterial. Available June 22nd. C-9084.

ELECTRICAL ENGINEER, 1930, age 31, single, U. S. citizen. Graduate from an engineering college of a "big-ten" university. Telephone and machine shop experience. Speaks Greek besides English. Wishes permanent position in any engineering field. Location, immaterial, go abroad. C-9075.

UTILITIES ASSISTANT EXECUTIVE or local manager. Trained mechanical, electrical, and refrigerating engineering. Experienced operating, construction, engineering, management, public relations, selling, general business administration, accounting. Most valuable to organization desiring to effect maximum economy operating moderate sized property or division larger property. Now engaged, own business. Willing to prove value to employer, salary moderate to start. C-9050.

ELECTRICAL ENGINEER, married, with 20 years' electric utility operating experience in engineering, construction, maintenance of distribution and transmission lines. Substations, first-aid and educational work. Experience in solving radio interference problems. Can qualify as electrical superintendent or assistant to manager. Proved record of qualifications. C-7700.

GRADUATE ELECTRICAL ENGINEER, B. S. degree 1928, single, age 25. Two years' electrical distribution experience; one year of research work. Desires position with a public utility or manufacturing concern. Willing to start at bottom of any work with a future. Available on short notice. Location preferred, Eastern United States. C-7341.

TECHNICAL GRADUATE desires position with public utility. Twelve years' experience on overhead transmission and distribution, design, estimates, field checks, etc. Age 37, married. B-9248.

ELECTRICAL AND RADIO ENGINEER, four years' experience in research and development. Designing, constructing, servicing, and experimenting with radio circuits, amplifiers, vacuum tubes, and sound recording. Three years with research bureau of power company. Testing, checking, and calibrating laboratory instruments, relays, station apparatus. Prefers New York or vicinity. C-3087.

ELECTRICAL ENGINEER, 1928 graduate of a recognized university, 26, single. One year public utility experience, 1½ years as special apprentice on large electrified railroad. Available on short notice. C-9112.

ELECTRICAL ENGINEER, 34 years old, with extensive machine-shop experience in production and maintenance; also power house, and machine designing. Graduate of Cooper Union Institute of Technology. Willing to go anywhere. Good reference. C-1360.

SWITCHBOARD ENGINEER, age 30, single, American citizen, German college education. Six years practical electrician. Five years with Westinghouse Electric and Railway Supply Co. Thoroughly familiar with design, layout and construction of slate and steel panels. Expert in wiring diagrams; power and control circuits, relay applications and metering schemes. C-9037.

PROFESSOR OF ELECTRICAL ENGINEERING, 32, married, B. S. (E. E.) and E. E., three years with General Electric Company, five years with public utility, four years' teaching and administrative experience in state university. Excellent references. Available for next academic year. Correspondence invited. C-7152.

ELECTRICAL ENGINEER, 1930, B. S. in E. E., 24 years old, desires connection, any kind of work except sales or radio. Location, immaterial. C-9105.

GRADUATE ELECTRICAL ENGINEER, age 28, married, 8 years of industrial control, power plant design, and construction supervision experience with contractor. Desires position with public utility or manufacturing concern's engineering or construction departments. Location desired, Middle West. C-4428.

ENGINEER, age 42, electrical wiring layouts for industrial plants and buildings of a large variety for engineers, contractors and architects; also experienced in construction and operation. Location desired, New York City or Northern New Jersey. B-5068.

GRADUATE ELECTRICAL ENGINEER, 25, B. S. degree '29. Nineteen months' experience on general electric test, including 8 months as assistant foreman and foreman of power mercury arc rectifier test. Desires connection with operating or construction company in East or Middle West. C-9089.

ELECTRICAL ENGINEER, graduate, 33, married, 13 years' office and field experience design and construction power plants, substations, distribution systems, industrial electrifications, etc. Familiar with motors and control; some steam experience. Six years in Latin-America in positions of responsibility; fluent Spanish. Used to handling men. Seeks permanent connection in U. S. A. C-8553.

ELECTRICAL DESIGN DRAFTSMAN OR CHECKER, age 31, single, fourteen years' experience on power plant, high- and low-voltage substation and automatic railway substation design. Equivalent of college education. Available immediately. Location, immaterial. B-8628.

PROFESSOR OF ELECTRICAL ENGINEERING, Ph. D., wishes position as head of department of electrical engineering in a growing institution. Excellent general electrical engineering teaching and practical experience. B-660.

GRADUATE ELECTRICAL ENGINEER, 31, single, 8 years' experience, design and construction of transmission lines. voltages up to and including 220 kv., outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location, immaterial. C-3564.

ELECTRICAL ENGINEER, 28. Nine years' varied experience with power and communications companies. Successful design and supervision of experimental apparatus construction. Special transmission work with network and cables. A-c. measurements, high-voltage test, telephone plant work. Graduate Georgia Technology cooperative course. Location, preferred, New York or vicinity. C-9044.

GRADUATE ELECTRICAL ENGINEER, of Purdue University with 18 years' experience in design, construction, estimating, costs, valuation and appraisal of power plants, substations, transmission lines and industrial plants including five years in heavy electric traction and rapid transit work. Open for opportunity with future. C-8256.

SALES ENGINEER, electric specialties; experience in utilities engineering, also illumination and fixture manufacture. Available with two weeks' notice. Salary or commission. C-2942.

ELECTRICAL ENGINEERING GRADUATE, experienced in sales, contact, lecturing and promotion work. Desires position as representative along utility or heavy-duty industrial equipment lines. Location, Eastern preferred. B-4067.

1929 GRADUATE, E. E., age 23, married. One year experimental work on steam turbines, half year laboratory assistant to research engineer of electric manufacturing company. At present unemployed. Location, immaterial. C-9132.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering: cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense and cost analysis. Capable organizer. Profitable assistant to busy executive. Prefers East. Consider any proposition. B-9122.

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RECENT GRADUATE ELECTRICAL ENGINEER, single, age 25. Desires engineering work. Has had experience in drafting. Location, United States or foreign. Available immediately. C-8437.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, 24, married, excellent physical condition. One year's experience in electric-shovel construction. Desires position with future. Location and salary immaterial. Best of references. Available at once. C-9142.

MECHANICAL - ELECTRICAL ENGINEER, American, 37 years old, six years in charge of factory manufacturing 700 tons of raw sugar daily, factory employing 250 men. Has done considerable original work in welding. Capable of supervision of the design, layout, construction of plants handling large tonnage. C-9052.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, age 25 and single. Experienced in machine-shop and steel-construction work. Four years of practical and theory of electricity in college. Willing to start at the bottom and work up with a reliable company. Available at any time. Location anywhere in United States. C-9135.

GRADUATE ELECTRICAL ENGINEER, 24, two years' manufacturing experience. Desires position on university staff with opportunity to work on Master's degree. Available September. C-9157.

1931 GRADUATE ENGINEER, single, age 24. B. S. in E. E. from University of Kansas in June. Prefers junior engineer work in public utility or manufacturing concern. Willing to begin at bottom where ability, productivity, and personality will produce advancement. Good student. Best of references. Available June 1931. Anything anywhere considered. C-9094.

ELECTRICAL ENGINEER, American, 40, married. Experienced in power generation, transmission, distribution and application to industrial uses. Work covers layout, constuction, operation, maintenance, and repairs. Desires position as electrical engineer with manufacturing concern generating its own power or with utility company. Speaks Spanish. Available on reasonable notice. C-502.

SWITCHBOARD FOREMAN, 10 years' experience with construction companies for public utilities, wiring, construction and installation of power house switchboards and control apparatus. Shop experience, manufacturing switchboards. C-4831.

MANAGER OR SUPERINTENDENT, 47, married. Executive, electrical or industrial. Successful organizer, efficient operator. Knows men; can handle them. Expecially interested in properties not now paying, where future depends on results. Reads, writes, speaks Spanish. Capable earning six thousand up. Available reasonably short notice. Location, not particular; prefers Western United States. C-8777-312-C-1-San Francisco.

ELECTRICAL ENGINEER, B. S. in E. E. 1930, age 25, single. Some steel mill operating experience. Now employed on G. E. test. Desires permanent position with utility company in construction, maintenance, or design work. Good references and personality. C-9159.

GRADUATE ELECTRICAL ENGINEER, 1930, single, six months on Westinghouse engineering course covering tests on switchboards, circuit breakers, regulators, motors, generators, etc. Nine months supervising telephone conduit and cable plant construction and telephone cable testing. Excellent physical condition. Desires permanent position with good future. Location, immaterial. C-9158.

ELECTRICAL ENGINEER, college graduate, 31, married. Eleven years in station, transmission, and distribution designs; system operation and planning; superintendence of meter and relay department; studies, reports and calculations. Good theoretical as well as practical background. Accustomed to responsibilities. Prefers New York or environs but will consider good proposition elsewhere. B-9401.

1930 GRADUATE ELECTRICAL ENGINEER, 23, single. Has had four months on Westinghouse Student Course and considerable industrial experience preceding graduation. Desires to connect with a public utility company. Location, immaterial. Available on two weeks' notice. Good references. C-9150.

ELECTRICAL ENGINEER, B. S. in E. E., 1927, single. Twenty months' experience in design and testing of fractional hp. motors; two years' industrial plant experience. Familiar with motors and control equipment. Desires position as electrical engineer. Location, immaterial. C-9168.

ASSISTANT PROFESSOR OR INSTRUCTOR IN ELECTRICAL ENGINEERING, 33, married, six years' administrative and teaching experience both E. E. and M. E. subjects. Position desired with technical school in South or West where opportunity is offered for advanced study and research. Available September. C-9166.

Membership

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before May 31, 1931.

Anderson, F. E., Dept. of Public Works, State of Calif., Sacramento, Calif.
Angle, W. P., Virginia Electric & Power Co., Richmond, Va.
Archer, E. T., (Member), E. T. Archer & Co., Kansas City, Mo.
Atkinson, E. S. (Member), H. B. Sherman Mfg. Co., Battle Creek, Mich.
Beavers, M. F., General Electric Co., Pittsfield, Mass.
Becker, F. G., Electrical Trades School, Cincinnati, Ohio
Benson, C. R., General Electric Co., San Francisco, Calif.
Betz, L. G., Public Service Electric & Gas Co., Hackensack, N. J.
Blum, R. A., Buffalo General Electric Co., Buffalo, N. Y.
Brackett, C. H., Union Carbide Co., Niagara Falls, N. Y.
Brennan, J. J., Memphis Power & Light Co., Memphis, Tenn.
Browne, T. E., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Bunker, F. C., (Member), General Electric Co., Houston, Tex.
Byron, T. J., New York Telephone Co., Albany, N. Y.
Cain, W. W., Consolidated Gas Co., New York, N. Y.
Cutting, F. S., (Member), 98 Carolina Ave., Providence, R. I.
Donabar, H. F., 2325 No. 50th St., Milwaukee, Wis.
Drew, C. E., (Member), R. C. A. Institute, Inc., New York, N. Y.
Duncan, R. L., (Member), R. C. A. Institute, Inc., New York, N. Y.
Durnin, E. J., Saskatchewan Power Commission, Saskatoon, Sask., Can.
Eason, R. K., General Electric Co., Beaumont, Tex.
Edwards, D. V., Electrons Inc. of Delaware, Newark, N. J.
Edwards, G. W., Cleveland Railway Co., Cleveland, Ohio
Ellis, E. A., Atlantic Electric Co., Boston, Mass.
Essington, H. M., (Member), Chicago Surface Lines, Chicago, Ill.
Findlow, C. W., Amalgamated Electric Corp., Toronto, Ont., Can.
Frank, W., 312 Fredericka St., North Tonawanda, N. Y.
Fuller, H. W., Saskatchewan Power Commission, Regina, Sask., Can.
Gallagher, D. H., Public Service Electric & Gas Co., Orange, N. J.
Garstang, W. W., P. R. Mallory & Co., Inc., Indianapolis, Ind.
Gilliatt, C. F., Toronto Hydro Electric System, Toronto, Ont., Can. (Applicant for re-election)
Gledhill, C. L., Public Service Electric & Gas Co., Newark, N. J.
Hillebrand, A. G., Spicer Mfg. Corp., Toledo, Ohio
Hogg, T. H., (Member), Hydro-electric Power Comm. of Ontario, Toronto, Ont., Can.
Horn, R. S., Ray dio Ray Corp., Spokane, Wash.
Jansson, M. E., D. Van Nostrand Co., Inc., New York, N. Y.
Jenkins, R. D., Atchison, Topeka & Santa Fe Railroad, Albuquerque, New Mexico
Johanson, C. G., Jr., N. E. P. Engg. & Service Corp., Boston, Mass.
Johnson, G. W., Texas Power & Light Co., Palestine, Tex.
Krauer, O., Otis Elevator Co., Yonkers, N. Y.
Lancaster, H. W., The Bristol Co., Akron, Ohio
Lawrence, W. H., Syracuse Lighting Co., Inc., North Syracuse, N. Y.
Leavy, M., Haaren High School, New York, N. Y.
Lewis, W. P., American Steel & Wire Co., Worcester, Mass.
Lines, M. B., Mountain States Tel. & Tel. Co., Denver, Colo.
MacKenzie, N. H., United Engineers & Constructors, Newcastle Creek, N. B., Can.
MacLaughlin, R. R., American Tel. & Tel. Co., Cleveland, Ohio
Malone, D. L., Student, Delta, Pa.
Marcroft, H. C., Pennsylvania Water & Power Co., Holtwood, Pa.
Marsden, H. M., Hartford Steam Boiler Inspection & Insurance Co., New York, N. Y.
McCall, C. C., Cleveland Electric Illuminating Co., Cleveland, Ohio

McCarren, R. P., Anaconda Copper Mining Co., Anaconda, Montana
Michelsen, C. H., 4456 Douglas Rd., Toledo, Ohio
Miller, H. E., General Electric Co., Philadelphia, Pa.
Miller, R. H., (Member), 524 Liberty Bldg., Des Moines, Iowa
Morrison, A. C., Duke Power Co., Charlotte, No. Car.
Morse, J. A., New England Tel. & Tel. Co., Boston, Mass.
Nelson, J. W., Park Coal Co., Leechburg, Pa.
Nelson, L. V., Union Electric Lt. & Pr. Co., St. Louis, Mo.
Osborne, J. I., Dept. of Institutions & Agencies, Holmdel, N. J. (Applicant for re-election)
Osterberg, E. T., Illinois Bell Telephone Co., Chicago, Ill.
Owens, F., Brooklyn Edison Co., Brooklyn, N. Y.
Pearson, D. S., General Electric Co., Erie, Pa.
Perkins, E. F., Allied Engineers, Inc., Jackson, Mich.
Perkins, W. J., General Electric Co., Philadelphia, Pa.
Persons, J. H., General Electric Co., Atlanta, Ga.
Phelan, C. S., U. S. Shipping Board, New York, N. Y.
Phillips, R. J., Scranton Electric Co., Scranton, Pa.
Port, R. F., Syracuse Lighting Co., Syracuse, N. Y.
Pullen, W. S., (Member), Alaska Electric Lt. & Pr. Co.; Juneau Ferry & Navigation Co., Juneau, Alaska.
Ranney, W. E., Washington Water Power Co., Spokane, Wash.
Rebsamen, L. M., City Water & Light Plant, Jonesboro, Ark.
Reif, W. H., The Montana Power Co., Bozeman, Montana
Robinson, L. E., Chicago Rapid Transit Co., Chicago, Ill.
Saft, A. J., N. Y. C. High Schools, New York, N. Y.
Shifrin, L. I., National Crafts Supply Co., New York, N. Y.
Simon, A. B., Jr., Senior, Purdue University, W. Lafayette, Indiana
Smith, E. F., University of Florida, Gainesville, Fla.
Stewart, W. J., N. J. Power & Light Co., Holland, N. J.
Taylor, E. H., Westinghouse Elec. & Mfg. Co., East Springfield, Mass.
Welch, E. S. (Member), Southern Indiana Tel. & Tel. Co., Seymour, Indiana
Williams, A. R., (Fellow), 4 Ogden Ave., White Plains, N. Y.
Young, E. W., Edison Electrical Illuminating Co. of Boston, Boston, Mass.
Zak, F. J., Virginia Electric & Power Co , Richmond, Va.
Total 84

Foreign

Ganguli, A. K., E. I. Railway, Allahabad, India
Hill, J. B., Pernambuco Tramways & Power Co., Ltd., Pernambuco, Brazil, So. America
Minocha, K. R., International General Electric Co., Ltd., Lahore, India
Nath, N., Principal Service Electrical Engg. College, Rawalpindi, India
Pritchard, A. C., H. M. Prison Commisioners, Walton, Liverpool, England
Total 5

Transfers

Recommended

The Institute's board of examiners at its meeting of March 25, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

McNEELY, JOHN K., professor of elec. engg., Iowa State College, Ames, Iowa.
PETURA, FRANK J., general purchasing engr., Henry L. Doherty & Co., New York.
REID, HARRY, president, Electric Management & Engineering Corp., New York.

To Grade of Member

ALMQUIST, MILTON L., telephone engr., American Tel. & Tel. Co., New York.
BAILEY, JULIAN C., general engr., Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.
BARNES, MARION S., sales agent, General Electric Co., San Francisco, Calif.
CANFIELD, DONALD T., asst. professor of elec. engg., Purdue University, Lafayette, Indiana.
CASEY, EDWARD A., district engr., Anaconda Wire & Cable Co., New York.
CASSELL, RAYMOND L., asst. to president, W. S. Lee Engineering Corp., New York.
CHAMPREUX, ALFRED J., transmission and protection engr., Pacific Tel. & Tel. Co., Seattle, Wash.
COFFIN, JOHN R., engr., Jackson & Moreland, Boston, Mass.
COPELAND, MARK W., Voorhees, Gmelin & Walker, New York.
DIEFENDERFER, JOHN H., asst. to supt. of distribution, Pennsylvania Power & Light Co., Hazleton, Pa.
FARNHAM, WILLIAM E., local traffic engineer, American Tel. & Tel. Co., New York.
FAWCETT, ORVILLE E., maintenance engr., West Penn Power Co., Pittsburgh, Pa.
FOERSTER, JOHN A., general electrical supt., City Hall, Prince Albert, Sask., Canada.
FRANK, AUGUSTUS A., chief engineer, N. Y. Telephone Co., New York.
GORHAM, ROBERT C., asst. prof. of elec. engg., University of Pittsburgh, Pittsburgh, Pa.
GRISWOLD, DEMETRIUS W., manager and chief engr., The British Plaster Board Ltd., Cheshire, England.
KENT, HARRY E., asst. engr., National Electric Light Association, New York.
LANE, FREDERIC ALLEN, electrical engr., American Gas & Electric Co., New York.
LITTLE, THOMAS J., manager, transmission sales dept., Anaconda Wire & Cable Co., New York.
PARKER, CARLETON H., asst. line signal supervisor, United Electric Railways Co., Providence, R. I.
RODRIGUEZ, RODOLFO CID, chief electrical engr., National Railways of Mexico, Mexico, D. F.
ROYDEN, GEORGE T., division engr., Mackay Radio & Telegraph Co., San Francisco, Calif.
TOWNSEND, ARTHUR, chief inspector, Saskatchewan Power Commission, Regina, Sask., Canada.
TULLAR, CHARLES E., manager, patent dept., General Elec. Co., Schenectady, N. Y.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during March are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

AVIGATION. By Bradley Jones. N. Y., John Wiley & Sons, 1931. 314 pp., illus., diagrs., 8 x 5 in., cloth. $2.75.——A brief textbook, intended to give the aviator a practical knowledge of the subject. The instruments used, methods of computing distance and track, drift correction standard and short methods for finding position by astronomic methods, radio navigation and fog flying are discussed.

TURBINEN-SCHNELLAÜFERN, Theorie und Bau. By Viktor Kaplan and Alfred Lechner. München, R. Oldenbourg, 1931. Illus., diagrs., 10 x 7 in., cloth. 18-r. m. ——This book, which is an entirely rewritten edition of Professor Kaplan's former work, "Bau der rationellen Francis Turbinen-Laufraeder," contains an account of the practical and theoretical results of his many years of experimental work upon high-speed turbines, and of the development of the Kaplan turbine. The principles of runner design and methods of regulation are set forth and illustrated by actual installations. Professor Lechner presents a summary of the hydromechanical investigations that have interest to the turbine designer, and a statement of turbine theory.

SYMPOSIUM ON AIRCRAFT MATERIALS. American Society for Testing Materials. Phila., 1930. 192 pp., illus., diagrs., 9 x 6 in., cloth. Price not indicated.——Contains eighteen papers by various engineers discussing matters of metals, alloys, woods and textiles used in constructing aircraft, aircraft finishes, the use of stampings and castings, failures of engine parts, specifications, mechanical and X-ray testing, welding procedure and heat treatment.

INDUSTRIAL ACCIDENT PREVENTION; a Scientific Approach. By H. W. Heinrich. N. Y., McGraw-Hill Book Co., 1931. 366 pp., illus., tables, 8 x 6 in., cloth. $4.00.——A very thorough presentation of the essential principles of accident prevention, based upon long practical experience. The author describes, step by step. the procedure for determining the causes of accidents, the selection and application of the remedy, safety psychology, etc. Many good methods of guarding machinery are shown.

AMERICAN DIESEL ENGINES. By L. H. Morrison. N. Y., McGraw-Hill Book Company, 1931. 606 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.——This book will interest the prospective purchaser and the operating engineer. It discusses comparative costs of Diesel and steam plants, the operation and adjustment of Diesel engines and their suitability for various kinds of work. It also gives descriptions of engines being made at present in this country, and parts.

Standard Four-Figure Mathematical Tables. 2 vols. (1 vol., Edition A; 1 vol., Edition B). By L. M. Milne-Thomson and L. J. Comrie. Lond. & N. Y., Macmillan Co., 1931. 245 pp. each vol., diagrs., 11 x 8 in., cloth. $4.50 each vol.——This work is intended to provide a comprehensive table of the numerical values of the elementary functions that are in constant use in the applications of mathematics in physics, engineering, statistics, etc. It includes a number of tables on trigonometrical functions with the argument in radians, hyperbolic functions, inverse trigonometrical and hyperbolic functions, natural logarithms and powers of *e*. Edition A has positive characteristics in the logarithms; edition B, negative characteristics

Relays in Automatic Telephony; Their Construction, Design and Adjustment, together with the Theory of Impulsing and the Measurement of Time Lags. By R. W. Palmer. N. Y., Isaac Pitman & Sons, 1930. 192 pp., illus., diagrs., 7 x 5 in., cloth. $3.00.——A textbook in which the subject is explained clearly and simply.

Qualitative Chemical Analysis. By Herman T. Briscoe. N. Y., D. Van Nostrand Co., 1931. 279 pp., diagrs., 9 x 6 in., cloth. $2.25.——A comprehensive treatment of the subject, intended for students with some knowledge of general chemistry. The first half of the book presents the theories and principles of electrolytic solutions and the properties of the various anions and cations which are involved in the analytical procedures. The second half gives a practical laboratory course.

Organization Engineering. By Henry Dennison. N. Y., McGraw-Hill Book Co., 1931. 204 pp., 8 x 5 in., cloth. $2.00.——This book discusses the problems of group action and points out some of the conditions necessary for effective organization work. The characteristics of human nature are surveyed, methods for guiding and increasing joint productivity considered, and the principles of organization structure set forth.

Illuminating Engineering Equipment, Theory and Design. By L. B. W. Jolley, J. M. Waldram and G. H. Wilson. N. Y., John Wiley & Sons, 1931. 709 pp., illus., diagrs., tables, 10 x 6 in., cloth. $12.00.——Starting with an account of the fundamental principles of illumination, the authors next describe the varieties of electric lamps used as sources of light, and then take up the question of lighting equipment. This topic is the major one of the book and is treated at length. The types of equipment for various purposes; their mechanical design; reflecting, diffusing and refracting media; projecting systems; color media; and equipment for the stage, advertising, studios, etc. are discussed. A section is also devoted to auxiliary equipment. Of use to everyone interested in the selection of equipment.

Commutatrices et Convertisseurs Rotatifs. By M. Barrère. Paris, J. B. Baillière et Fils, 1931. Illus., diagrs., 9 x 6 in., paper. (No price given).——A practical textbook upon the theory and design of rotary converters.

Communication Networks, v. 1; Classical Theory of lumped constant networks. By Ernst A. Guillemin. N. Y. John Wiley & Sons, 1931. 425 pp., diagrs., 9 x 6 in., cloth. $5.00.——Existing texts on the principles of communication, the author states, deal with the theory and practical significance of special types of networks commonly used in radio or telephone circuits. In the present book an attempt is made to take a broader view, by considering matters that are not of direct practical use, and thus to give the student a more thorough grasp of the fundamental methods of attack upon network problems in general. A succeeding volume on the theory of lines, cables and filters will appear next fall.

Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots and Reciprocals of all Integer Numbers up to 10,000. 3rd edition, edited by L. J. Comrie. London, E. & F. N. Spon, 1930. 208 pp., 9 x 6 in., cloth. 7/6.——For 90 years Barlow's Tables have been printed from the plates prepared for De Morgan's edition of 1840. The present edition is reset from modern type, and advantage taken of the opportunity to restore certain tables omitted from the second edition, some valuable new ones added, and certain other improvements effected.

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Maintained as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

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(May 1931) Number	Author	Title
☐ **31-12**	J. W. Milnor and G. A. Randal	The Newfoundland-Azores High-Speed Duplex Cable
☐ **31-36**	J. H. Ashbaugh	Automatic Regulators in Industries
☐ **31-44**	R. N. Southgate, A. S. Brookes, E. R. Whitehead and W. G. Roman	Impulse Tests on Substations
☐ **31-68**	B. F. Bailey	Measurement of Noise in Electrical Machinery
☐ **31-73**	E. A. Bishop	Noise Mitigation in Substations
☐ **31-76**	E. H. Hull and W. C. Stewart	Elastic Supports for Isolating Rotating Machinery
☐ **31-78**	Quentin Graham, Sterling Beckwith, and Frank H. Milliken	Magnetic Noise in Synchronous Machines
☐ **31-80**	T.G. Castner, E. Dietze, G.T. Stanton, and R. S. Tucker	Indicating Meter for Measurement and Analysis of Noise
☐ **31-81**	H. B. Marvin	The Measurement of Machinery Noise
☐ **31-84**	J. P. Foltz and W. F. Shirk	Induction Regulator Noise

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in Electrical Engineering. Thereafter a charge of twenty-five cents per complete copy will obtain.

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Selected Items *From* Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translation of foreign articles at cost.

Arcs

ELECTRIC. Dynamisches Verhalten des Lichtbogens nach Untersuchung mit dem Kathodenoszillographen (Dynamic Behavior of Electric Arc According to Study With Cathode Ray Oscillograph), H. Klemperer. *Archiv fuer Elektrotechnik*, vol. 25, no. 1, Jan. 27, 1931, pp. 73-80, 15 figs. Purpose of study is to investigate whether arc, after elapse of 1/100,000,000 sec., already has properties of stationary arc.

Armatures

WINDINGS. Die einfache Ausfuehrung der Bruckloch-Ankerwicklungen fuer Wechselstrom (Simple Method for Design of A-C. Armature Windings), T. Seike. *Elektrotechnik und Maschinenbau*, vol. 49, no. 2, Jan. 11, 1931, pp. 21-29, 13 figs. Simplified method for laying out of a-c. windings in which number of slots per pole and phase contains fractional value; method is developed for three-phase windings but can equally well be applied to single phase windings.

Atmospheric Electricity

MEASUREMENTS. Ueber die Messmethoden der elektrischen Leitfaehigkeit der Atmosphaere (Measuring Methods for Electric Conductivity of Atmosphere), J. Scholz. *Physikalische Zeit.*, vol. 32, no. 3, Feb. 1, 1931, pp. 130-139, 4 figs. Two sensitive apparatus were used to exclude meteorologic influences; it was shown that in comparative measurements, if possible, determination of potential gradient with radioactive sounding equipment should take place at great distance from location of observation, as deviations of over 100 per cent were often noticed.

Cables

FAULT LOCATION. Finding Cable Sheath Faults, J. Erickson. *Elec. World*, vol. 97, no. 9, Feb. 28, 1931, p. 409, 1 fig. Simple method, that makes use of only 6-volt battery, galvanometer and length of wire, has been found to be unusually accurate in locating conductor-to-sheath faults in lead-covered parkway cable on series street lighting systems.

INDUCTANCE. The Inductance Coefficients of a Part of a Circuit, and Their Applications, A. Russell. *Inst. Elec. Engrs.—Jl.*, vol. 69, no. 410, Feb. 1931, pp. 270-280, 9 figs. Theoretical mathematical study applied to electric cables and their sheath losses.

INSULATING MATERIALS. Cable Terminal Box Compounds, E. Woodrow. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 355-358, 1 fig. Defects that arise in insulating compounds and properties that are required; characteristics of what is considered ideal compound, and methods used and precautions to be taken in filling terminal box with such compound.

LEAD SHEATHING. Lead Sheaths for Cables, N. A. Allen. *Elec. Rev.*, vol. 108, nos. 2777 and 2778, Feb. 13, 1931, pp. 275-276 and Feb. 20, pp. 321-322, 5 figs. Cables with pure-lead sheaths will, sooner or later fail; examples of cases where this may have been are cited; notes on lead-improving alloys; lead-antimony research.

LOSSES. Contributo Allo studio delle perdite e dell'autoinduzione dei cavi unipolari armati con fili di ferro (Losses and Self Induction in Steel Armored Single-Conductor Cables), L. Bosone. *Elettrotecnica*, vol. 18, no. 1, Jan. 5, 1931, pp. 2-8, 6 figs. Distribution of magnetic field in armor and calculation of losses; diagrams and tables checked by experimental research. Bibliography.

OIL-FILLED. Oil Reservoir on Cable Joint Saves Material, O. L. Riggs. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, p. 465, 1 fig. Material and pole space may be saved in three-conductor type "H" aerial cable by mounting oil reservoir on joint itself; in this way running of long hose from pole to joint may be avoided.

Oil-Filled Cable Lines in London, C. E. G. King. *Elec. Times*, vol. 79, no. 2050, Feb. 19, 1931, pp. 231-234, 12 figs. 66,000 volt oil-filled cable of British grid system which are now in operation linking up Hammersmith, Battersea and Fulham power stations of London Power Company.

TELEPHONE. Telephone Cables—N. A. Allen. *Elecn.*, vol. 106, no. 2753, Mar. 6, 1931, pp. 360-361, 3 figs. Recent improvements in design of short distance types for subscribers' circuits.

TESTING. Earth Currents, R. N. Pegg. *Elec. Rev.*, vol. 108, no. 2779, Feb. 7, 1931, p. 370, 2 figs. Tests indicate that small currents in cable sheaths do not necessarily denote high-resistance faults.

Circuit Breakers

COMPRESSED AIR. Latest Developments in Compressed-Gas Circuit Breaker Design, O. Mayr. *AEG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 30-32, 8 figs. Outdoor type of compressed-gas breaker up to 100-kv. working voltage and its operating characteristics.

OIL. Neuer Motorschutz-Oelschalter mit Fernbetaetigung (Novel Remote Control Protective Motor Oil Circuit Breaker), A. Cohn. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 259-260, 6 figs. AEG-MSBO equipment for 550 volts, 60 amperes is non-interlocked push-button control remote control breaker, suitable for heavy duty intermittent operation; bi-metal stripping is used; high speed magnetic short circuit is employed which makes interrupting of currents up to 10,000 amperes possible.

TANK PRESSURE. Pressure Phenomena in Oil-Circuit Breakers, W. M. Leeds. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 152-156, 14 figs. Oscillograph records of pressure in medium and high-speed breakers show that tank walls are subjected to pressure surges of very steep wave-front having definite frequency between 10 and 60 cycles per sec.; from results of large number of laboratory tests, theory has been developed to account for these pressure waves.

Condensers

Synchronous Versus Asynchronous Condensers, A. Mandl. *AEG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 47-53, 5 figs. It is investigated in which instances it is advisable to employ synchronous or asynchronous condenser; subject matter is based on condensers of medium and large capacity; range of output between 6000 and 60,000 kva. for regulating voltage of correspondingly large networks.

POWER FACTOR IMPROVEMENT. Starkstrom-Kondensatoren zur Blindstrom-Kompensation und ihre Wirtschaftlichkeit in Industrieanlagen (Electric Condensers for Reactive Power Compensation and their Economy in Industrial Installations), H. Cypra. *Elektrizitaet im Bergbau*, vol. 5, no. 11, Nov. 15, 1930, pp. 216-219, 6 figs. Advantages over rotating phase correcting machinery; no-load consumption of condensers practically is negligible, they do not need supervision and require no extra operating room; AEG equipment is illustrated.

SYNCHRONOUS. Developments in Hydrogen-Cooled Condensers, C. J. Fechheimer. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 165-169 and 178, 5 figs. Devices incorporated to safeguard equipment in practically every conceivable way are briefly described, repetitions of previous publications being avoided wherever possible; it is believed that tendency in future will be toward simplification, and reduction in number of auxiliary devices; test results are given. Bibliography.

Control

BRIDGES. Variable Voltage Control Improve Bridge Operation. *Elec. West*, vol. 66, no. 3, Mar. 1, 1931, pp. 141-143, 3 figs. West Spokane Street Bridge in Seattle; from engineering standpoint is unique not only in layout and design of its apparatus but also because it is first on Pacific coast and one of first in country to utilize advantages of variable voltages for controlling leaf movement; by use of separate motor-generator set, source of variable armature voltage is provided for regulating speed of driving motors.

REGENERATIVE. Le freinage électrique en courant continu des trains sur pentes (Electric Braking with Direct Current of Trains on Slopes), E. Gratzmuller. *Industrie Electrique*, vol. 40, no. 926, Jan. 25, 1931, pp. 33-42, 5 figs. Tentative study of principles in braking with recuperation of energy under normal speed and transitory high speeds.

Regenerative Control in Paris, Bacqueyrisse. *Tramway and Ry. World*, vol. 69, no. 8, Feb. 12, 1931, pp. 83-84. Reply to British viewpoint of regenerative control; application to British Systems; gear ratio; reports on damage.

Converters

FREQUENCY. Frequency-Changers, S. Neville. *Power Engr.*, vol. 26, no. 299, Feb. 1931, pp. 46-49. Characteristic types, limitations and operating features of synchronous, induction-synchronous and asynchronous frequency changers.

Dielectrics

Contribution to the Theory of Dielectrics, G. Gueben. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 11, no. 69, Feb. 1931, pp. 405-410. It is supposed that current in dielectric is due both to contribution of dipoles and to presence of ions; part due to each of these two elements is determined and formula is proposed for general expression of current in solid dielectric.

Modern Theories of Dielectrics, W. N. Stoops. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 183 and 185. Two of first questions asked about any new insulating material have to do with its dielectric constant and its power-factor; within recent years, understanding of these properties of dielectric has increased greatly; general discussion of modern conceptions is given.

Dynamometers

ELECTRIC. The Dynamo-Electric Machine as a Dynamometer, B. P. Haigh. *Engineering*, vol. 131, no. 3394, Jan. 30, 1931, pp. 129-131, 12 figs. Modifications required to enable standard dynamo or motor to measure torque in its shaft, and certain precautions that should be observed in order to obtain accurate results; examples installed in Engineering Laboratory of Royal Naval College, Greenwich, are illustrated.

Education

ENGINEERING. Some Facts about the Scholastic Achievements of Engineering Students, H. W. Miller and J. C. Palmer. *Jl. Eng. Education*, vol. 21, no. 5, Jan. 1931, pp. 371-383, 9 figs. Investigation of results accomplished by segregating high and low students in classes by themselves.

Electric Drive

CANALS. The Welland Ship Canal—XVII. *Engineering*, vol. 131, no. 3395, Feb. 6, 1931, pp. 166-169, 15 figs. partly on p. 176. Whole of machinery required for operation of canal is electrically driven; complete system of electric lighting is installed and master of controls, interlocking and signaling are all electrically operated; power is purchased from Hydro Electric Power Commission of Ontario, power being transmitted over canal transmission line and transformed in and distributed from substations; on canal power is used mainly for operation of locks and bridges, lighting and heating control houses and substations; details of electric equipment and insulation.

CEMENT PLANTS. Modernizing a Cement Works, S. Hopferwieser. *Brown Boveri Rev.*, vol. 18, no. 3, Mar. 1931, pp. 116-119, 11 figs. Various drives and equipment installed at S. A. des Ciments Portland de Lorraine, Strasbourg; by extensions and improvements made; daily production of plant was increased in this way from 160 tons to about 800 tons.

COAL HANDLING. The Use of Alternating Current for Handling Coal—I, R. F. Emerson. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 104-111, 12 figs. Conditions peculiar to handling of coal, coke and ashes, such as effect of these different kinds of dust on motor insulation and special precautions to be taken; handling of coal by coal towers, bridges and cranes, rotary-type car dumpers; equipment and performance characteristics.

STEEL PLANTS. An Electrified Steel Mill, R. H. Wright. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 146-149, 8 figs. Improvements completed last year in Alabama City plants of Gulf States Steel Co. make this one of most modern steel mills; 7000-hp. adjustable-speed d-c. reversing motor, capable of developing 19,000 hp. momentarily, drives 40-in. blooming mill; first installation of synchronous motors on roll mill; intermediate roll trains are driven by 2750-, 2100-, 1750- and 1300-hp. motors.

Electric Discharge

GLOW. On the Distribution of Space-potential in High Frequency Glow Discharge, D. Banerji and R. Ganguli. *Lond., Edinburgh, and Dublin Philosohpical Mag. and Jl. Science*, vol. 1, no. 69, Feb. 1931, pp. 410-422, 5 figs. Exploring collector method of Langmuir and Mott-Smith has been applied to study space-potential distribution, ionic concentration, current density, and average electronic velocity in case of high-frequency discharge through rarefied air and oxygen; it has been found that potential distribution is symmetrical about middle point of discharge-tube, both electrodes acting as cathodes in corresponding d. c. discharge.

Electric Equipment

DESIGN. Tendances actuelles dans l'équipement électrique des centrales (Present Trend in Design of Electric Powerplant Equipment), V. Clerin. *Union des Ingénieurs Sortis des Ecoles Speciales De Louvain—Bul. Technique*, no. 4, 1930, pp. 41-76, 23 figs. Development in high capacity electric powerplant and substation machinery and equipment in United States and Europe is reviewed and illustrated; wiring diagrams are given.

Electric Heating

The Heating of Buildings, D. J. Bolton. *Elec. Rev.*, vol. 108, no. 2777, Feb. 13, 1931, pp. 306-307. General considerations governing use of electricity for purpose; fuel costs of alternative systems; comparative efficiencies; capital expenditures; costs of operation; indirect advantages of electric heating; thermodynamic principles.

INDUSTRIAL. Industrial Electric Heating. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 365-369. Applications and advantages of electricity for industrial heating in which author points out that electricity competes successfully against other heating media on account of its advantages rather than its cost.

Electric Lines

GROUNDING. Earthing of E.H.T. Systems, J. Eccles. *Elec. Times*, vol. 79, no. 2050, Feb. 5, 1931, pp. 243-244, 3 figs. Practise of earthing e.h.t. transmission systems through tuned choke coils instead of through non-inductive resistances has been developed principally on continent and for certain systems it has indisputable advantages.

CALCULATION. Sinusoidal Currents in Linearly Tapered Loaded Transmission Lines, J. W. Arnold and P. F. Bechberger. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 2, Feb. 1931, pp. 305-310, 3 figs. Working formulas for calculation of input impedances and attenuation are obtained for transmission line in which resistance and inductance per unit length are linear functions of distance, and in which capacitance and leakance are constant; generalized functions depending on initial constants and rate of taper are introduced, in such way that formulas and functions are analogous to usual formulas and hyperbolic functions.

HIGH TENSION. Ueber ungleichmaessig verteilte Zusatzlast bei Hochspannungsleitungen mit Haengisolatoren (Unequally Distributed Additional Load in Electric High Tension Lines on Suspension Insulators), O. Strand. *Elektrotechnische Zeit.*, vol. 52, no. 10, Mar. 5, 1931, pp. 316-320, 6 figs. Method for calculation of all asymetric loading conditions for stranded conductors by which it is possible to determine irregularities in span, vertical load insulators, etc., in simple manner.

Electric Signs

NEON. A Short Analysis of the Neon Sign Situation, A. W. Murdock. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 49-50. As operating costs over 5-year period are only 25 per cent of incandescent signs large increase in their use may be expected.

Electrolysis

WATER PIPE. Why Prohibit Grounding of Telephone Cable Sheaths on Water Pipes, I. D. Van Giesen. *Water Works Eng.*, vol. 84, no. 3, Feb. 11, 1931, pp. 159-160 and 180 and 183, 6 figs. Report on experiments conducted by electrolysis engineer of Department of Water and Power, Los Angeles, Cal.; use and effects of a.c. and d.c. currents; dual nature of stress in charged conductor; joint use of poles causes trouble; noise reduced by grounding; investigation of noise arising from joint use of poles; effects of grounding; how ground is to be made. Before Am. Water Works Assn.

Furnaces

Les fours électriques a récupération aux usines citroen (Recuperative Electric Furnaces in the Citroen Plants). *Jl. du Four Electrique*, vol. 40, no. 1, Jan. 1931, pp. 11-13, 4 figs. Heat treatment equipment saving approximately 20 to 30 per cent of electric power over ordinary furnaces as usually employed in United States; two of this type of furnaces are installed in Citroen plant in Paris by Jean Aubé, in which parts of 500 cars produced in 24 hr. are handled; operation requires 4 men, against 10 men required by 12 old furnaces, which they replace.

HEAT TREATING. Electric Furnaces and Low-Temperature Treatments, J. E. Oram. *Metallurgia*, vol. 3, no. 15, Jan. 1931, pp. 94-96, 5 figs. Low-temperature heat-treatments offer additional scope to electric furnace; low operating and maintenance costs and ease of temperature control are associated with this type of equipment.

HIGH FREQUENCY. Hoegfrekvensugnen Ur Elektrisk Anlaeggningssynpunkt (High-Frequency Furnaces from Standpoint of Electric Engineers), J. Oesterberg. *Teknisk Tidskrift*, vol. 61, no. 1, Jan. 3, 1931, (Elektroteknik), pp. 8-12, 11 figs. General considerations in design of furnaces for melting of metal, and data on installations in Sweden built by AEG.

INDUCTION. Bisher unbekannte Badbewegungen bei Induktionsoefen (Heretofore Unknown Bath Movements in Induction Furnaces), E. F. Russ. *Giesserei*, vol. 18, no. 8, Feb. 20, 1931, pp. 165-166, 1 fig. Review of previous research on bath movements in induction furnaces, notably that of Hering and Northrup and formulation of pinch effect and Northrup effect; results of author's experiments, and conclusions based thereon.

LABORATORY. Beschreibung eines Zerreissofens (Tensile Testing Furnace), O. Holtschmidt. *Mitteilungen aus den Forschungsanstalten*, vol. 1, no. 2, Nov. 1930, pp. 40-44, 4 figs. Price 2.50 m. Requirements of laboratory furnace for testing influence of temperature on properties of steel, and description of electric furnace developed and perfected in course of eight years; elongation measurements.

Generators

ROTORS. Fatigue Tests of Model Turbo-Generator Rotors, R. E. Peterson. *Mech. Eng.*, vol. 53, no. 3, Mar. 1931, pp. 211-215, 10 figs. Results of tests of rotor end forgings to obtain data as to safety during operation; tests with fatigue loading only, and with superimposed centrifugal stressing.

STABILITY. Generator Stability Features Fifteen Mile Falls Development, R. Coe and H. R. Stewart. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 139-143, 9 figs. Generators in New England Power Association's 15 mile falls development are notable for several reasons; they are of new umbrella type which has but one guide and one thrust bearing, both located below rotor; to insure stability generators were built with especially low transient reactance, large flywheel effect special damper winding, and quick-response excitation system; electric and mechanical characteristics are discussed, notes on testing.

SYNCHRONIZATION. Measurement of the Load Angle of Synchronous Machinery, J. C. Prescott and E. W. Connon. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 410, Feb. 1931, pp. 281-289, 12 figs. Method of determining by direct measurement synchronizing power flowing to or from alternator for given angular displacement of rotor from normal running position; method was developed in connection with some experiments on natural free period of alternators, but results of measurements can be used to obtain effective reactance of machine and demagnetizing and cross magnetizing coefficients for armature field; experimental results are quoted.

WATERWHEEL. 20,000 Kva. Water Wheel Alternators. *Engineer*, vol. 151, no. 3971, Feb. 13, 1931, pp. 192-194, 9 figs. Large alternators forming initial generating plant of Waikaremoana hydroelectric power station of New Zealand constructed and installed by Metropolitan Vickers Electrical Co.; normal rating is 20,000 kva.; normally they are driven at 428 r.p.m. but are designed for overspeed of 85 per cent; current is generated at 11,000 volts and each generator feeds through its own bank of step-up transformers on to 110,000-volt busbars; lubrication is provided by low-pressure oil supply.

Water-Wheel Alternators; Trend of Development, F. Ruedenberg. *A EG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 17-22, 11 figs. Meticulously prepared designs have given A.E.G. assurance that construction of much larger hydro-power alternators (over 100,000 kva.) can be tackled while retaining fundamental arrangements approved for so many years and applying constructional materials obtainable at present day.

High Head Impulse Unit With Unique Control. *Elec. News*, vol. 40, no. 5, Mar. 1, 1931, pp. 31-34, 3 figs. Vancouver Island Power Co.'s Jordan River plant now complete with fourth unit; unit is 15,000-kva., 6600-volt, 60-cycle three-phase English electric generator, driven at 300 r.p.m. by two tangential water-wheels, one mounted on each end of shaft and overhanging bearings; waterwheels are together rated at 18,000 b.hp.; more than 1¾ mi. of steel penstock required.

Humming

ELECTRIC LINES. Le Ronflement des lignes aériennes et les perturbations atmosphériques (Humming of Aerial Lines and Disturbances in Atmosphere), A. Noden. *Académie des Sciences—Compte Rendus*, vol. 191, no. 20, Nov. 17, 1930, pp. 959-961; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 89, Feb. 1931, p. 91. Valuable meteorological information can be obtained from humming of aerial lines; two such lines, at right angles are installed at Biarritz observatory; humming, which as rule occurs in calm atmosphere, is attributed to electrostatic attractions provoked by successive small masses of highly charged air passing rapidly over line in direction at right angles to it.

Hydroelectric

EQUIPMENT. Some Outstanding Trends in Canadian Central Station Practise, D. Anderson. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 42-44, and 50, 5 figs. Tie-bank connections were constructed for interchange of power on Southern Canada and Shawinigan systems and on East Kootenay and Calgary Power systems; 8000 ft. river crossing was built to carry power from Falls River to Prince Rupert, B. C.; welded type generators have found broad application in new plants constructed; field of propeller runners was increased to 66 ft. head; notes on metal-clad switchgear, welded and umbrella-type generators, higher head propeller runners, long distance transmission spans.

PAPER MILLS. An Ideal Site Developed the High Falls Plant. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 39-42, 6 figs. James MacLaren Co. has filed plans with Dominion government for another development, of 120,000 ultimate hp. capacity with 200-ft. head at point farther down river between Buckingham and Masson; it is at latter town 25 miles below High Falls. that company has stepdown transformer station for its new large paper mill which went into operation last September; hydroelectric plant and transmission lines are described.

Insulation

PAPER. Paper Applications in Electrical Industry, W. H. Anderson. *Paper Trade Jl.*, vol. 92, no. 7, Feb. 12, 1931, pp. 39-41. Paper before Tech. Assn. Pulp and Paper Industry, indexed in Engineering Index 1930, from Paper Mill, Dec. 27, 1930.

PHENOLIC. Electrical Materials Commonly Used—Laminated Phenolic Insulation, W. C. Hirsch. *Elec. Mfg.*, vol. 7, no. 2, Feb. 1931, pp. 57-59, 2 figs. Laminated phenol-resinoid sheets range in size up to about 39 by 47 in.; thicknesses range from 1/64 to 5 in.; tubes and rods come in lengths of 18, 24, 36, and 48 in., ranging in diameter from 1/8 to 12 in. with 1/32- to 1½-in. wall thicknesses; rods range in diam. from 1/8 to 4 in.; there is almost no limit to variety of applications of this hard and tough material.

VARNISH. Insulating Varnishes, H. N. Bassett. *Elec. Times*, vol. 79, no. 2054, Mar. 5. 1931, pp. 433-434. Classification; solvents; impregnation and drying; examination and testing; other uses.

WOOD. Woods for Insulation, A. R. Dunton and A. W. Muir. *Elecn.*, vol. 106, no. 2750, Feb. 13, 1931, pp. 237-239, 6 figs. Varieties used; methods of impregnation; breakdown voltages of treated woods.

Lamps

GAS-FILLED. Gasfilled Lamps, A. E. Williams. *Elec. Rev.*, vol. 108, no. 2779, Feb. 27, 1931, pp. 371-372, 3 figs. Notes on chemical processes involved in their manufacture; arrangement of "gettering" apparatus; argon gas; gas pressure in lamp; chemical "getters."

GLOW. Low-Voltage Tube Lighting Available. *Elec. World*, vol. 97, no. 7, Feb. 14, 1931, p. 324, 1 fig. New era in commercial application of luminous tubes was forecasted in recent announcement by Claude Neon Lights, Inc. New York, of commercial production of units developed for general interior lighting on 110 volt and 220 volt service; rare gas tubes are now applicable to commercial, industrial and special residential lighting, and greatly increased range of color effects has been achieved.

Neon Tube Light and Factors Governing Its Life, R. R. Machlett. *Franklin Inst.—Jl.*, vol. 212, no. 3, Mar. 1931, pp 319-326. Electrical characteristics; function of pressure; sputtering; life effect of electrode material and of pressure on life of tube.

Lighting

Calcul de l'éclairage par projecteurs (Calculation of Lighting by Pro-jectors), G. Beylon. *Electriciens*, vol. 47, no. 1509, Feb. 1, 1931, pp. 60-62, 1 fig. Calculation of projected light is simple in theory but difficult and in exact when location of lighting equipment is close to surface to be lighted, simple numerical analysis for various cases is given.

SERIES. Standard and Proposed Cutout Designs for Series Street-Lighting Circuits, H. E. Butler. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 112-114, 2 figs. Inspection of designs, together with considerations showing that much study has been given to problem of developing best type of film cut-out (at present special-oxide form) for use on either low or high voltage series street-lighting circuits; cut-outs of new designs, special-oxide disk type and electromagnetic type will function satisfactorily at low-voltage rating.

Lightning

ELECTRIC LINES. Der Blitzschlag in Hochspannungsanlagen und seine Folgen (Lightning Striking in High Tension Lines and Consequences Thereof), E. Flegler. *Elektrotechnische Zeit.*, vol. 52, no. 5, Jan. 29, 1931, pp. 129-133, 4 figs. Form of resulting waves; requirements of protective equipment against excessive voltages are pointed out.

Meters

WATTHOUR. Checking Load and Power Factor from Watthour Meter Readings, M. A. Faucett and J. O. Kraehenbuehl. *Factory and Indus. Mgmt.*, vol. 81, no. 3, Mar. 1931, pp. 427-428. Determination of corrected power and power factor shown by example using G. E. meter of D-7 type, 100 amperes, three-phase and 220 volts.

Motors

DESIGN. Sub-Synchronous and Standard-Speed Motors. *Product Eng.*, vol. 2, no. 2, Feb. 1931, pp. 67-70, 8 figs. Advantages of subsynchronous motors which run at 200 r.p.m. or 600; practical discussion of proper methods in selection of motor for clocks, recording instruments and light power requirements. (Continuation of serial.)

DIRECT-CURRENT. Berechnung von Gleichstrommotoren nach preiswirtschaftlichen Gesichtspunkten (Calculation of D-C. Motors According to Economic Viewpoints as to Costs), R. Hofmann. *Elektrotechnik und Maschinenbau*, vol. 49, no. 5, Feb. 1, 1931, pp. 81-85, 1 fig. Determination of favorable pole and yoke inductions and of most advantageous magnetic flux; practical example is given.

FRACTIONAL HORSEPOWER. Closed Iron Ring Motor. *Elec. Times*, vol. 79, no. 2051, Feb. 12, 1931, pp. 282-284, 7 figs. Motor described presents some novel features in design and operates on entirely new principle; original invention was made by J. Zetsche, of Germany, in attempt to produce gramophone motor having superior characteristics to those of existing designs.

Modernize Wiring and Motors for Better Voltage Regulation, L. L. Elden. *Elec. World*, vol. 97, no. 9, Feb. 28, 1931, pp. 416-417. Failure to recognize merits of new developments in motor design and importance of more adequate wiring will result in many cases in poor service and economic losses which cannot be compensated for otherwise; figures on sources of poor regulation point to conditions which should no longer be overlooked by progressive power companies; test data on 387 motors causing lighting fluctuations; motor-starting currents and overloaded wiring causing complaints.

INDUCTION. Moteur asynchrone autocompensé a démarrage automatique (Self Compensated Induction Motor for Automatic Starting), P. Letrilliart and P. Fourquet. *Revue Générale de l'Electricité*, vol. 29, no. 5, Jan. 31, 1931, pp. 163-178, 15 figs. Mathematical analysis of principles, characteristics and performance of motor with 2 windings on rotor and 2 on stator.

OSCILLATING ARMATURE. Ein neuer Wechselstrom-Kleinmotor (Novel Fractional Horse Power A. C. Motor), C. Kuehnel. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 267-268, 3 figs. Oscillating armature motor by which armature oscillates synchronously which each half cycle around axle and then are converted into rotating motion is described; practical applications are discussed.

STARTING. Methodes de démarrage des moteurs asynchrones diphasés a cage d'écureuil (Methods for Starting of Two-phase Induction Motors with Squirrel Cage Rotor), Marre. *Electriciens*, vol. 47, no. 1510, Feb. 15, 1931, pp. 74-76, 6 figs. Various hook ups, their features and analysis.

TESTING. Eine neue Methode zur kuenstlichen Belastung von Induktionsmotoren (New Method for Artificial Loading of Induction Motors), A. M. Bamdas. *Elektrotechnik und Maschinenbau*, vol. 49, no. 5, Feb. 1, 1931, pp. 86-88, 2 figs. Method developed by author and S. B. Eliaschewitz by which stator and rotor are connected to separate networks.

Networks

DESIGN. Rural Electrification, A. Ekstrom and V. Ekstrom. *Elecn.*, vol. 106, no. 2753, Mar. 6, 1931, pp. 357-359, 2 figs. Simple method of calculating most economical cross section of conductor for given maximum permissible drop in voltage.

STABILITY. Power-system Stability—II, R. D. Booth and O. G. C. Dahl. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 131-141, 10 figs. Notes on generator design and reactance; line and transformer reactances; synchronous condenser size and reactance; load characteristics; voltage regulator and exciter characteristics; governor action; inertia of rotating machines; damper windings and their effects; effect of different grounding systems; effect of circuit-breaker operation; determination of transient operating characteristics.

Photoelectric

AMPLIFIERS. Ueber die Verstaerkung von Photozellenstroemen (Amplification of Current from Photoelectric Cells), H. Simon. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 264-266, 10 figs. Various types are described and possibilities of application are discussed.

COLOR MEASUREMENT. Photo-Electric Cell Has Definite Place in Color Measurement, W. M. Scott. *Textile World*, vol. 79, no. 8, Feb. 21, 1931, pp. 886-889, 4 figs. Uses, limitations and future possibilities of photoelectric cell; determination of light energy; recent developments.

Power

DOMESTIC. Poughkeepsie Plan Quintuples Domestic Usage, Triples Revenue, A. M. Perry. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, pp. 444-449, 4 figs. Domestic use of electricity has been nearly multiplied by five and revenue increased three times what it was just before "full-use" electric home plan was inaugurated by Central Hudson Gas & Electric Corp.; customers have changed from limited use of electric conveniences to "full-use" and obtained nearly five times as much energy as formerly for only half unit price, including amortization of equipment cost; analysis based on one year's experience of plan is given.

INDUSTRIAL PLANTS. Bringing Electric Power into the Small Plant, R. H. Rogers. *South Power Jl.*, vol. 49, no. 2, Feb. 1931, pp. 99-103, 7 figs. Accumulated experience of years in industrial electrification has determined certain practises and methods as being most successful from standpoints of procedures of power, insurance underwriters, and consumer; meter and lighting; practical application of electric drive; electric motor control.

Power Factor

Power Factor Determination, C. F. Dalziel. *Elec. West.*, vol. 66, no. 3, Mar. 1, 1931, pp. 124-126, 5 figs. Practical methods of measuring power factor and verifying reverse power relay connections in three-phase power systems. (To be continued.)

Power Plants

Steam and Diesel Units Combine to Give Low Over-all Power Costs. E. J. Kates. *South. Power Jl.*, vol. 49, no. 2, Feb. 1931, pp. 52-54, 2 figs. In power plants serving dual needs of power and steam, Diesel engine indicated as companion unit to steam prime mover, when power demand exceeds steam or heat demand; tabular results of comparative power cost studies for large department store.

Radio

AMPLIFIERS. Maximum Undistorted Power Output, G. Smiley. *Radio Eng.*, vol. 11, no. 2, Feb. 1931, pp. 36-39 and 50, 7 figs. Engineering analysis of factors determining amplifier design and performance.

CONDENSER LOSSES. The Losses in Variable Air Condensers, W. H. F. Griffiths. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 124-126, 5 figs. Method of analysis is amplified by omitting all reference to voltage or current, reasoning being based merely upon impedance triangle of capacity and resistance in series which gives well known simple expression for power factor, to high degree of approximation.

CONDENSER TESTING. By-Pass Condenser Production Test Equipment, F. W. Stellwagon. *Electronics*, vol. 2, no. 2, Feb. 1931, pp. 504-505, 5 figs. Grebe Co. uses by-pass condenser test apparatus capable of completely testing over 500 by-pass condenser units per hour; tests include ten-second test at 200 per cent of rated d-c. voltage, discharging of charged condensers, testing insulation between condenser terminals and container, and checking capacity of four condenser sections.

DISTORTION. An Analysis of Distortion in Resistance Amplification, E. B. Moullin. *Experimental Wireless*, vol. 8. no. 90, Mar. 1931, pp. 118-123, 4 figs. Method of predicting from static characteristic output of resistance coupled amplifier; certain form of equation is assumed for characteristic and this leads to simple rules for deducting fractional amplitudes of second and third harmonic currents.

RECEIVER TESTING. Special Instruments for Radio Receiver Production Testing, R. P. Glove. *Electronics*, vol. 2, no. 2, Feb. 1931, pp. 500-501, 4 figs. Notes on adaptation of Wheatstone bridge; condenser test equipment; visual test apparatus; production testing of audio amplifiers; loud speaker testing.

TUNING. Selectivity and Response, E. E. Wright. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 133-134, 1 fig. Attempt to find from theoretical reasoning response of selectivity tuned circuit to steadily modulated wave.

Railroad

ELECTRIFICATION. West Side Freight Electrification of New York Central Railroad, W. J. Hedley and J. F. Walker. *Gen. Elec. Rev.*, vol. 34, no. 3, Mar. 1931, pp. 165-169. 7 figs. West side improvement involves, in addition to electrification work being carried out by Railroad Company, variety of other changes which are being done jointly with City of New York, including elimination of tracks from streets and provision of space for high speed traffic roadway from Canal Street and West Street to 79th Street and Riverside Drive; notes on road freight locomotives; switching locomotives; operating conditions.

The Reading-Philadelphia Suburban Electrification, G. I. Wright and A. I. Totten. *Gen. Elec. Rev.*, vol. 34, no. 3, Mar. 1931, pp. 173-179, 13 figs. Enlargement of service to include through passenger and freight traffic; single-phase, 25-cycle, 12/36-kv., three-wire system, as finally decided upon, consists essentially of frequency-changer station at Wayne Junction to be owned by Philadelphia Electric Company; initial peak load, in suburban zone, will approximate 9000 kw. or about 13,000 kva.; frequency-changer station; distribution system; multiple-unit cars; traction motors; control and auxiliary equipment, are discussed.

SIGNALING. Automatic Block Signaling on the Canadian Pacific Railway, A. K. Kidd. *Elec. News*, vol. 40, no. 5, Mar. 1, 1931, pp. 39, 40 and 42, 3 figs. Semaphores are being replaced with colored light signals which may have effective range from 3000 to 4000 ft. in bright sunlight; most recent development in signaling is centralized traffic control.

D. and H. Handles Four Ends of Double Track by Centralized Control. *Ry. Age*, vol. 90, no. 8, Feb. 21, 1931, pp. 411-412, 3 figs. Installation between Center Village, New York, and Lanesboro, Pa. has solved operating problem on two short sections of single track and permits closing of four offices; operating characteristics; outside construction; track and signal plan of centralized traffic control territory.

Substations

High Power Mercury Arc Rectifiers, N. von Kotschubey. *Elec. Times*, vol. 79, no. 2053, Feb. 26, 1931, pp. 377-380, 6 figs. Description of substation plant of new South Wales government railways and tramway system Sydney; adoption of mercury arc rectifiers not only simplified service conditions of N.S.W. Government railway substations, and reduced operation costs by increasing over-all efficiency of plants, but also considerably lowered initial cost of substations; tables showing how costs of three 1500-kw. 1500-v. rotary converter units at Belmore compare with those of identical rectifier substation at Epping.

Rate Making

POWER INDUSTRY. Electric Power Supply in the Limelight, L. R. Nash. *Stone and Webster Jl.*, vol. 49, no. 2, Feb. 1931, pp. 84-92. Public utilities supply more than two-thirds of electricity used; electric service highly developed in South; domestic and rural service; casual service rates below cost, service charge; rural rates; further rate practises; electric rates lower than general price level.

The Domestic Tariff, C. F. Mounsdon. *Elec. Rev.*, vol. 108, no. 2776, Feb. 6, 1931, pp. 232-233. It is claimed that practical difficulties experienced in use of any single-basis two-part tariff would be obviated by introduction of composite basis for fixed charge.

Relays

PROTECTIVE. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 172-178, 16 figs. Overcurrent relays for generator differential protection; ratio-differential relays for generator protection; overspeed protection of generators; generator field protection; undervoltage time-delay protection for motors; synchronous condenser protection; synchronous-converter protection; motor-generator protection; protection of frequency-changer sets.

Safety Devices

ELECTRIC APPLIANCES. The Safety of Domestic Electrical Appliances, G. W. Stubbings. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 373-374. Various methods that are employed with view to increasing safety, viz., earthing, construction of insulating material, low working voltage, and use of leakage relays; author points out that each has certain shortcomings, and therefore further research into safety methods is necessary.

Ship

ELECTRIC EQUIPMENT. The Electrical Equipment of Ships, J. E. Allen, vol. 131, no. 3395, Feb. 6, 1931, p. 191. Difference in practise between electricity at sea and on land; totally enclosed motors, specially designed to prevent entry and deteriorating effects of moisture, oily vapor, salt-laden air and seawater; use of contactors for making and breaking first step of starting resistance; deck machinery; rubber-insulated cables. Before Inst. Mar. Engrs.

Starters

MOTOR. Small A-C. Motor Starters, J. P. S. Pillans. *Elec. Rev.*, vol. 108, no. 2779, Feb. 27, 1931, p. 369. With view to providing all desirable operation and protection features at moderate cost author suggests modification of simple switch-fuse.

Substations

HEATING. Electric Heat for Substation and Office Buildings, P. Sporn. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, pp. 463-464, 3 figs. Number of substations and office buildings on properties of various subsidiaries of American Gas & Electric Co. have been equipped with electric storage type heating systems; in Hall system employed in all these installations water is heated by direct contact with totally inclosed immersion units; general basis on which to make calculations for justifying or disproving economic feasibility of electric heating, is outlined.

Switches

VACUUM TUBE. A Vacuum-tube Time Switch, W. K. Kearsley. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 128-129, 2 figs. Type of equipment described is outcome of developmental work to produce time switch that has no moving parts; in it, vacuum tubes and other static electrical equipment accomplish what is ordinarily considered to be functions of mechanisms and motion.

Switchgear

LOSSES. Eddy Current Losses in Heavy Current Switchgear—I, J. E. Shaw. *World Power*, vol. 15, no. 86, Feb. 1931, pp. 109-113, 7 figs. Measurement of iron loss in large oil switch tanks and switch tops with 5000 amps. flowing in loop conductor; methods adopted for obtaining conditions similar to those in practise; from results obtained on various sizes of switch tanks and switch tops empirical formulas are derived whereby losses may be estimated in any desired case to within 10 per cent and thence temperature rises estimated. (To be continued.)

Telephone

CARRIER CURRENT. Practising Economy in Carrier Operation, F. D. Dommerque. *Telephone Engr.*, vol. 35, no. 2, Feb. 1931, pp. 33-34, 1 fig. Loading coils are not practical on long distance lines when repeaters are introduced, but economical for straight toll lines and cables. (Continuation of serial.)

Transformers

DESIGN. Design Features of World's Largest Transformers, H. L. Cole and F. J. Vogel. *Elec. World*, vol. 97, no. 8, Feb. 21, 1931, pp. 374-377, 5 figs. World's largest power transformers; are located at Roseland, N. J., switching station of Public Service Electric & Gas Company; they form two 90,000-kva. transformer banks, with one spare unit stepping from 220,000 Y volts to 132,000 Y volts (or vice versa), with 60,000-kva., 11,000-volt delta-connected tertiary winding for supplying synchronous condensers; they are oil insulated, self cooled by radiators, single-phase units; 132,000-volt winding is made up of two separate windings, each of one-half capacity, for connection to double bus transmission system.

Transformer Developments. *World Power*, vol. 15, no. 86, Feb. 1931, pp. 130 and 133-134, 4 figs. Design and operating characteristics of "grid" transformer under construction for Central Electricity Board; record of export work carried out by British Electric Transformer Co., Ltd., in recent years.

INSTRUMENT. Ueber die Anforderungen an Stromwandler in Kraftwerken (Requirements of Current Transformers in Power Plants), G. Keinath. *Elektrizitaetswirtschaft*, vol. 30, no. 3, Feb. 1931, pp. 60-68, 9 figs. Summary of developments regarding properties, degree of exactness; secondary output; rating, class and current overloading capacity, test voltage and operating voltage, construction, system of insulation, thermal strength; excessive current rating, dynamic strength, surge proofness.

Calculation of Instrument Transformer Burdens, T. A. Hammond. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 115-126, 19 figs. Significance of burdens; effect of burden magnitude on accuracy; errors from secondary leads; single-phase burdens; effect of secondary interconnections.

Transients

An Experimental Method of Studying Transient Phenomena, H. M. Turner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 2, Feb. 1931, pp. 268-281, 14 figs. Description of experimental method of studying transient phenomena which, by repeating phenomena synchronously enables one to observe it on screen of oscillograph as long as desired; method is based upon use of transient visualizer.

REFLECTION. Zur Metallreflexion (Metallic Reflection), J. Zahradnicek. *Zeit. fuer Physik*, vol. 65, no. 11-12, Nov. 14, 1930, pp. 814-823; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 89, Feb. 1931, p. 88. Theory of phenomena of reflection of plane; linearly polarized electromagnetic wave at metallic surface is developed from Maxwell's equations and appropriate boundary conditions; formulas for refractive index and index of absorption are given which are more general than those deduced by Drude for normally incident wave; suggestions for experiment at different angles of incidence are made and tables given.

TESTING. High-Voltage Surge Testing, F. D. Fielder. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 161-164, 7 figs. Oscillograph would have limited value without auxiliary circuits and devices which make it integral part of testing circuit; timing system must be available to sweep beam across film at proper instant and at known speed of one to sixty mi. per sec.; test surges must be reduced without distortion to few hundred volts for measurement; oscillograph must be synchronized with surge generator to within fraction of microsecond.

Trolleys

TRACKLESS. The Modern Trolley Bus as a Central Station Load Builder, C. A. Burleson. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, p. 130, 1 fig. Advantages of trolley bus as compared with street car are lower investment; elimination of track and paving charges; curb loading and unloading; flexibility in traffic; quiter operation; faster schedules; as compared with gas bus: lower operating cost; unlimited power supply; higher schedule speeds; better lighting and heating; quieter operation; absences of fumes; less fire hazard; cost of power is low and stable.

Maintenance and Operating Factors of Trolley Buses, G. W. Wilson. *Elec. Traction*, vol. 27, no. 2, Feb. 1931, pp. 79-81, 2 figs. Operating and maintenance costs compared and methods employed to eliminate various difficulties in service; solving braking difficulties; acceleration and distance curves showing relative performance of trolley buses and gas buses. Before Assn. Equipment Men, Southern Properties.

Vacuum Tubes

CATHODE RAY. Further Advances in the Technique of the Braun Tube, M. von Ardenne. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 127-129, 4 figs. Cathode-ray tube for photographic recording, with new small type for visual observation is described; complete circuit of new cathode-ray equipment is given.

DETECTOR. High Level Plate Circuit Rectification, J. R. Nelson. *Electronics*, vol. 2, no. 3, Mar. 1931, pp. 550-551, 3 figs. Experimental procedure for attacking problem of plate rectification with large input voltages is receiving considerable attention at present; necessary experimentally determined curves may be obtained very easily so that anyone with measurable a-c. voltages and fairly accurate d-c. milliammeter may plot his own rectification characteristics for resistance load; characteristics curves of 227 tubes are given.

RECTIFIER. Zur Theorie eines Gleichrichters mit fallender, hyperbelfoermiger Kennlinie (Theory of Rectifier with Decreasing Hyperbolic Characteristics), O. Stierstadt. *Elektrische Nachrichten-Technik*, vol. 8, no. 1, Jan. 1931, pp. 31-38, 7 figs. Performance of rectifier tube is mathematically analyzed.

Welding

ARC. Arc Welding in 1931, J. F. Lincoln. *Boiler Maker*, Feb. 1931, pp. 50-51, 1 fig. Review of developments in arc welding during past year; equipment and processes; arc welding in structural engineering.

Arc Welds Cut Repair and Maintenance Bills, B. S. Havens. *Mill and Factory Illustrated*, vol. 8, no. 3, Mar. 1931, pp. 40-43, 14 figs. Examples of different applications. (To be continued).

ELECTRODES. Die Untersuchung von Elektroden fuer die Lichtbogenschweissung (Studies of Electrodes for Arc Welding), S. Sandelowsky. *Elektroschweissung*, vol. 2, no. 3, Mar. 1931, pp. 48-52, 15 figs. Strength of weld; texture of weld; shrinkage and stresses; economy. (Concluded.)

BRIDGES. Bemerkenswerte Schweissarbeiten an einer Eisenbahnbruecke (Welding of Railroad Bridge), E. Fromme. *Elektroschweissung*, vol. 2, no. 2, Feb. 1931, pp. 35-36, 4 figs. Modernization and making suitable for modern train traffic of 2500-m. long Moerdyk Bridge, in Holland, by electrically welded movable supports.

CAST IRON. The Use of Pure Iron Electrodes for Welding Cast Iron, H. D. Lloyd and J. S. G. Primrose. *Welding Jl.*, vol. 28, no. 328, Jan. 1931, pp. 18-22, 8 figs. Advantages of pure iron electrodes in making bed plate and repair electric motor casings; microphotographs illustrate burnt on weld in cast iron; phosphoric cast iron welded with soft pure iron.

MONEL METAL. Some Practical Notes on Welding Monel Metal. *Machy. (Lond.)*, vol. 37, no. 960, Mar. 5, 1931, pp. 733-734, 3 figs. Properties and use of monel metal with data on welding procedure; advantages of metallic arc welding of castings.

PIPE LINES. Pipe Line Welding, W. T. Graham. *Welding Engr.*, vol. 16, no. 2, Feb. 1931, pp. 42-44, 4 figs. Methods of preparing and welding of pipe developed by A. O. Smith Corporation; eight generator gangs consisting of foreman, mechanic and nine welders (one spare man) will produce average of 220, 10-in. weld, or 175, 16-in. welds or 132, 20-in. welds, or 110, 24-in. welds per 9-hr. day.

PRESSURE VESSELS. Welding Plates and Pressure Vessels, P. R. Hawthrone. *Welding*, vol. 2, no. 2, Feb. 1931, pp. 89-92, 5 figs. Tests show that by use of proper welding process, procedure control and method of annealing, welded vessels are made stronger than riveted ones.

Wiring

BUILDINGS. Vertical Distribution in World's Tallest Structure, J. A. Walsh. *Elec. World*, vol. 97, no. 7, Feb. 14, 1931, pp. 328-334, 10 figs. Empire State Building has frontage of 200 ft. on Fifth Avenue and 420 ft. on both 33d and 34th streets; gross floor area in 85 stories is 2,800,000 sq. ft. and rental area is slightly under 2,000,000 sq. ft.; 85th floor is 85 by 135 ft.; estimated connected load is 6000 kw. for lighting and 9600 hp. for power services; this estimate for connected lighting load was based on assumption of 6 amp. per ultimate lighting circuit; details of installation are given.

Industrial Notes

Anaconda Acquires Cable Accessories.—The Cable Accessories Corporation, formerly of Pittsburgh, and purchased by the Anaconda Wire & Cable Company, has been moved to the Hastings-on-Hudson, N. Y., plant, and is now operating to provide a complete cable service, including potheads, junction boxes, insulating compounds, jointing and miscellaneous materials.

Lincoln Electric Promotes George G. Landis.—According to a recent announcement, the Lincoln Electric Company, Cleveland, manufacturers of "Linc-Weld" motors and "Stable-Arc" welders, has advanced George G. Landis to the position of chief engineer. He has been with the company eight years. Many of the patents held by his employers, both on arc-welding equipment and electric motors, are the result of his work.

The Ohio Brass Company, Mansfield, Ohio, announces receipt of a contract from the Pennsylvania Water and Power Company covering all suspension insulators and hardware for its new 220-kv. transmission line connecting the Safe Harbor power development and Baltimore. This line, one of the most important in the system operated by Pennsylvania Water and Power Company, will serve Baltimore's industries.

Foster Wheeler Enters Boiler Industry.—With the acquisition of the plant and business of the D. Connelly Boiler Company, of Cleveland, the Foster Wheeler Corporation announces that it is prepared to furnish all types of boilers in the entire range of sizes and pressures. The Connelly Company was established more than fifty years ago. The Foster Wheeler Corporation has been supplying complete steam generators for some time, and has produced the various parts in its own works, with the exception of the boiler proper.

Inca Moves Eastern Office.—The Inca Manufacturing Division of the National Electric Products Corporation, has moved its eastern office from Newark, N. J., to 233 Broadway, New York. The new office, which includes both sales and service organizations, is under the direct supervision of Paul Stouffer. The main plant and general office are located in Fort Wayne, Ind., where a complete line of magnet wire and coils for the radio and electrical industries is manufactured. The eastern warehouse and coil winding department will continue to be maintained.

New Small Motors.—The Century Electric Company, St. Louis, announces a new line of fractional horsepower motors having mounting dimensions interchangeable,—in repulsion-start induction single-phase, split-phase single-phase, squirrel cage induction three-phase, and direct-current types. The bearing brackets of this design offer unusual protection against falling objects, dirt, or dripping water. The motors have rolled steel frames, welded steel feet, slotted for belt adjustment, and bearings machined from phosphor bronze castings.

New Underground Cable.—A new underground cable, known as "Flexlay," has been designed and is being manufactured by the National Electric Products Corporation, Pittsburgh. It is a flexible, highly insulated underground wiring system and is produced in three different types: non-metallic, semi-metallic and full-metallic which is better known as Parkway Cable. Flexlay may be laid in open trench without damage from abrasive handling, eliminating the use of clay or fibre ducts. It is so constructed as to adequately resist the action of soil textures, soil acids and prevailing moisture contents.

Large Turbine Order to Westinghouse.—The Public Service Electric and Gas Company at Newark, New Jersey, has recently awarded the Westinghouse Electric & Manufacturing Company an order for a 75,000 kw., 60 cycle, single-cylinder steam turbine-generator unit to be installed as the No. 6 steam unit at the Kearny generating station and which will bring the capacity in this station up to approximately 290,000 kw. The new unit will receive part of its steam from the mercury vapor condensers serving the 20,000 kw. G. E. mercury-vapor unit recently ordered from the General Electric Company.

In addition to the above the Public Service Electric and Gas Company has also ordered an 18,000 kw., high pressure, 60-cycle Westinghouse turbine unit for the Burlington generating station, to operate in connection with new boiler equipment on 650 pounds. With the addition of this new high-pressure turbine, the Burlington station is being remade into a most economical generating station and will be capable of developing approximately 55,000 kw. The approximate value of the two steam turbine units ordered from the Westinghouse Electric and Manufacturing Company is $1,250,000.

C. S. Knight, Jr., manager of the electrical and wire rope sales department of the American Steel & Wire Company, Chicago, died recently at the Worcester (Mass.) office of the company. Mr. Knight was 66 years old and a native of Worcester.

Trade Literature

Pole Top Switches.—Bulletin 36, 4 pp. Describes Pacific Electric type PS-1 pole top switches for light branch line construction where very moderate loads are to be controlled. Pacific Electric Manufacturing Corp., 5815 Third Street, San Francisco.

Lightning Arresters.—Booklets 2 and 3, 12 and 8 pp., respectively. Describe the construction and operation of crystal valve lightning arresters. Electric Service Supplies Company, 17th & Cambria Streets, Philadelphia.

Load Testing Set.—Bulletin, 2 pp. Describes a load testing set for measuring current without interruption to service. The complete equipment consists of a newly designed, highly efficient split-core current transformer, and a Weston ammeter, complete with connecting cable and plugging device. The entire equipment, with carrying case, weighs ten pounds. Electrical Engineering Sales Company, Los Angeles and San Francisco.

Illumination.—Bulletin A-1204, 24 pp., "Banishing the Twilight Zone from Modern Buildings." A discussion of present-day principles and practise in the interior lighting of modern buildings. Bulletin A-1206, 32 pp., "Bringing Cities Out of the Twilight Zone." A discussion of modern street lighting, presenting reasons and methods for providing well illuminated cities. Bulletin A-1208, 24 pp., "Skylines Beyond Twilight Zone." Discusses modern principles and practise in floodlighting. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Carbon Brush Manual.—Catalog B-131, 24 pp. This book differs from the ordinary carbon brush catalog, being designed to simplify the selection and specification of carbon and metal-graphite brushes. The new shunt nomenclature of the National Electrical Manufacturers Association has been adopted. The essential details for a complete brush specification are listed and discussed in the sequence which has been found most convenient. Tables of physical characteristics have been omitted. Instead, a cross index of grades and their applications simplifies the selection of a suitable grade for any service. Examples illustrate the manner in which the composite specification for a brush is derived and the price computed. National Carbon Company, Inc., Cleveland.

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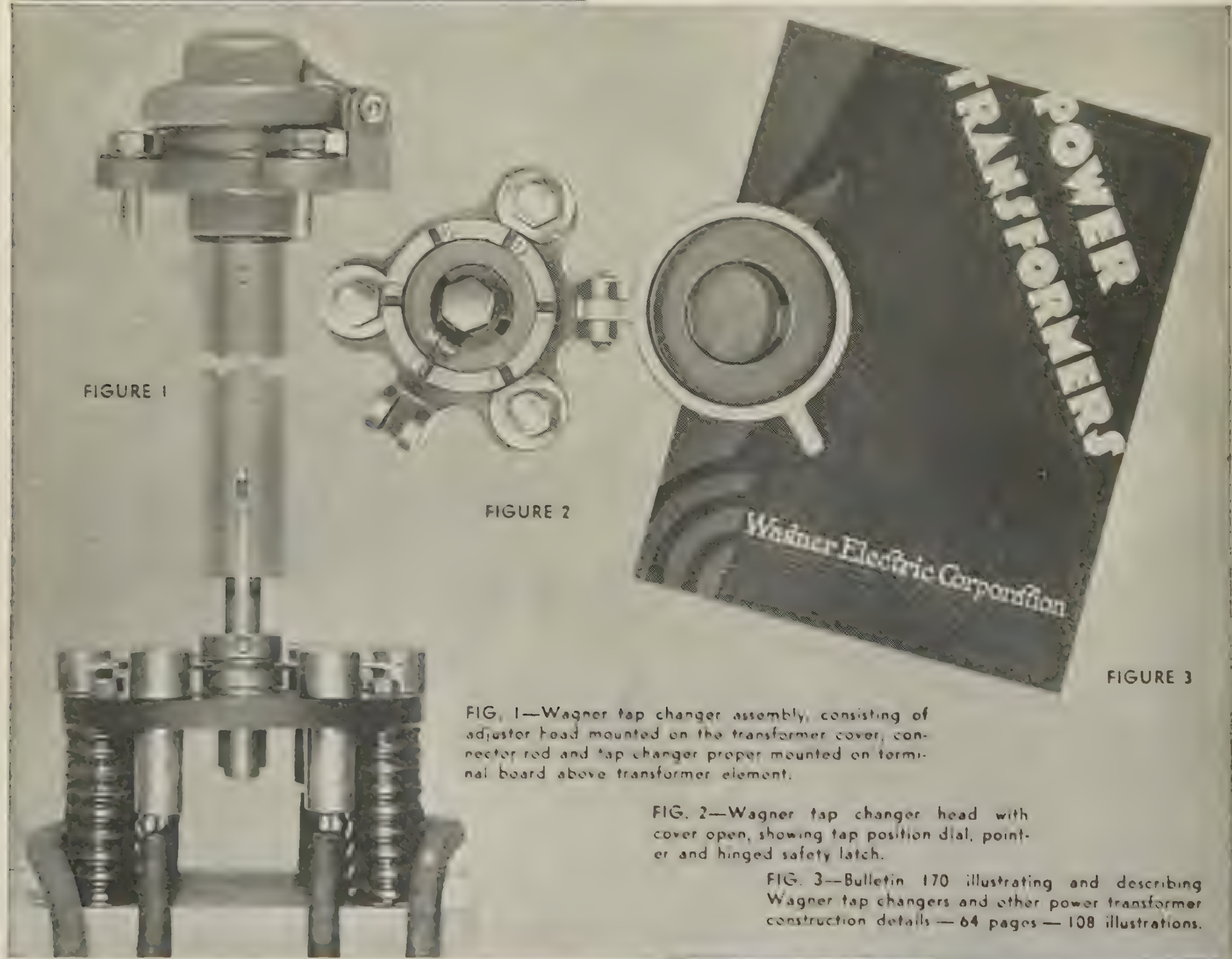

FIGURE 1

FIGURE 2

FIGURE 3

FIG. 1—Wagner tap changer assembly, consisting of adjustor head mounted on the transformer cover, connector rod and tap changer proper mounted on terminal board above transformer element.

FIG. 2—Wagner tap changer head with cover open, showing tap position dial, pointer and hinged safety latch.

FIG. 3—Bulletin 170 illustrating and describing Wagner tap changers and other power transformer construction details — 64 pages — 108 illustrations.

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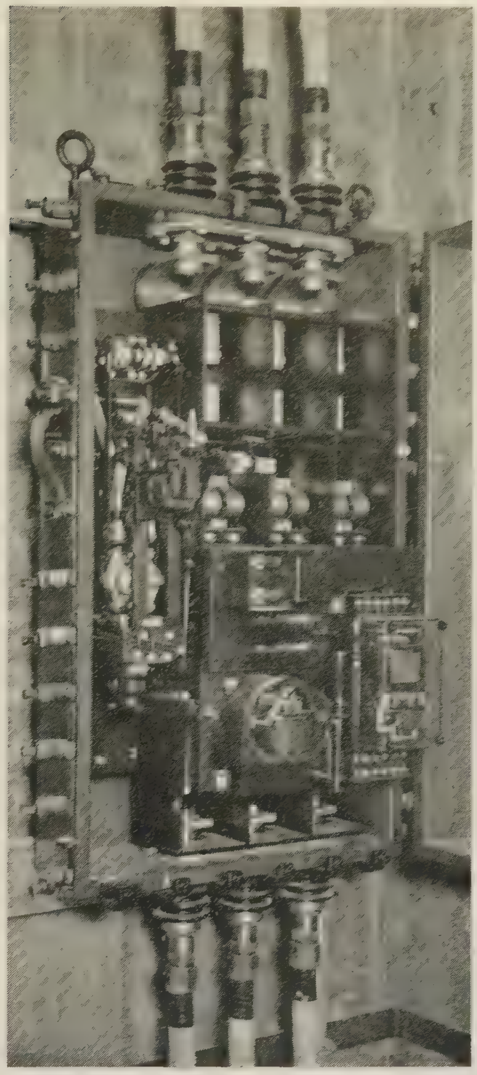

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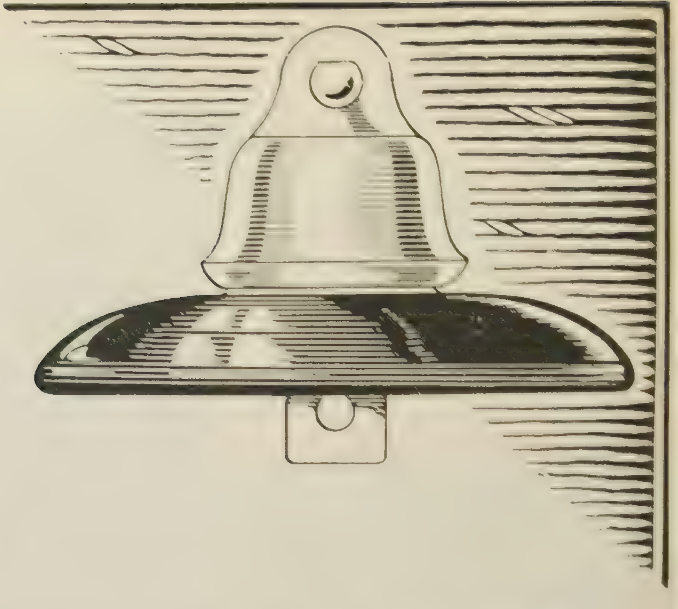


". and then take service records.

We introduced the high strength suspension insulator practically twenty years ago after convincing ourselves that the increase in strength represented no increased hazard in operation, but did provide an increased safety factor and consequently greater efficiency and longer life. Thousands of those old insulators went into service under the worst possible conditions and established reputations that are still being talked about.

Take one case for example. In 1916 a small high strength insulator was wanted on a railroad electrification. Space was a limiting factor so yoke sets and such other cumbersome and expensive methods of attaining additional strength were definitely out. We furnished a regular 8″ suspension disc, 5¾″ spacing, rated at 16,000 pounds.

That was fifteen years ago.

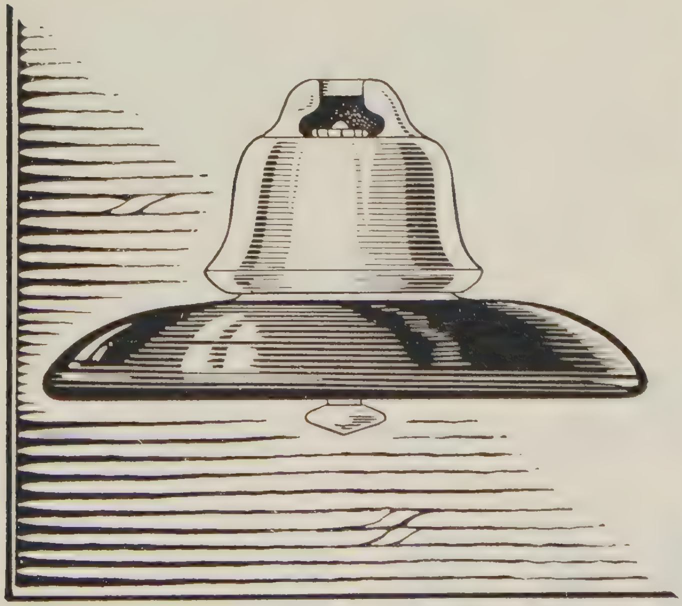
Today that original installation is 100% perfect and has been ever since the insulators went into the air despite the dirt and steam conditions under which the insulators had to operate and the other natural hazards incident to transmission through a countryside where lightning is severe.

When we say—as we do of our standard 18,000 pound insulator—that Locke Insulators will last as long as the line, we are merely reiterating what time has proved."

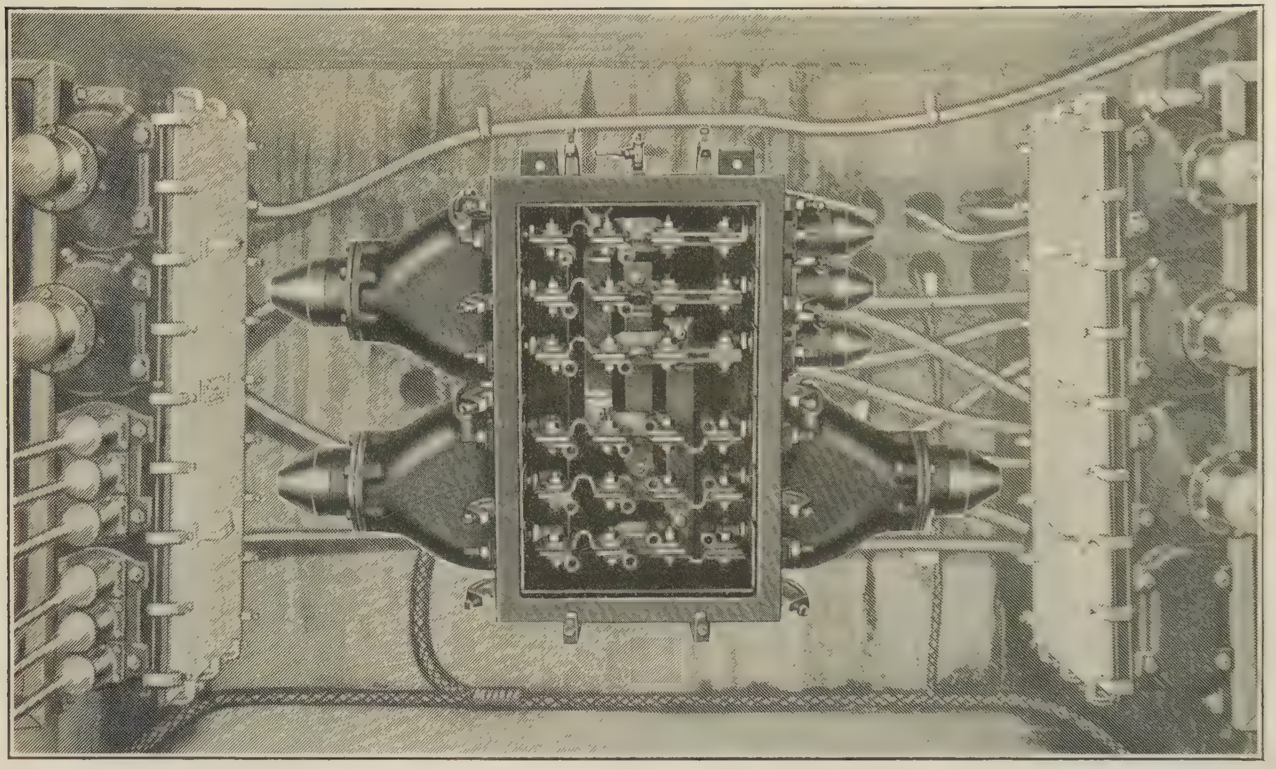
LOCKE PORCELAIN INSULATORS

LOCKE INSULATOR CORPORATION

BALTIMORE - - MARYLAND



G&W UNDERGROUND BOXES . . .



. . . EXACTLY suited to YOUR job

THE boxes installed are G&W Type "A", eight way, three conductor, for 600 volt service. They were made exactly for the job, and there was no price penalty. Note the interchangeability of cable heads to accommodate single or multiple conductor cables. And the flexibility of the inner structure. Changes in the system will not obsolete these boxes! The same contact fittings are used for either solid links or copper fuses. G&W boxes have light weight covers for easy handling, held down with "C" clamps which cannot be lost. Hardware is corrosion resisting throughout. Machined, flanged surfaces effectively gasketed make every G&W box air-tight. Bus structure is of cold drawn copper, and is well taped. Every detail is correct.

We can make this box problem easy for you—as we do for the man working with G&W equipment in a cramped manhole. Send us the installation data and let G&W work out the details for you and recommend a box that will be exactly suited to your particular job.

A GOOD LAYOUT DESERVES G&W BOXES

Potheads · Subway Boxes · Cable Terminal Devices · Automatic Transfer Switches

G&W Electric Specialty Co.

7780 Dante Avenue, Chicago · · · · Representatives in Principal Cities

Consider the

PYREX POWER INSULATORS

Economy of Permanence

When you are building your new lines weigh these facts:

•PYREX insulators withstand lightning surges of 1½ million volts, power arcs of 2,000 amperes for 2 seconds; they are unaffected by sun heat; they can be visually inspected through to the pin-hole.

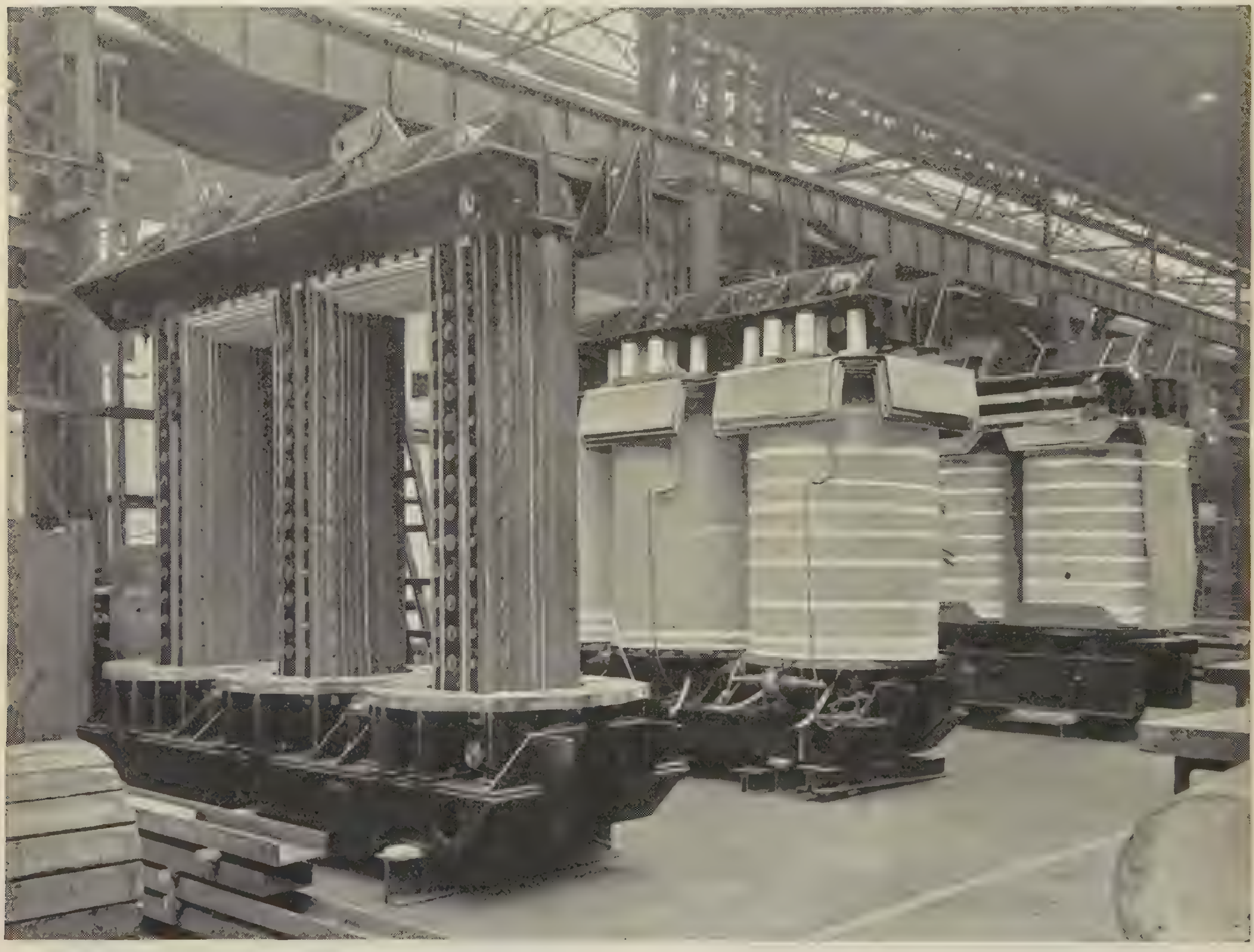
Then consider that these characteristics are inherent in PYREX electrical glass. They can never change.

Equip your lines with PYREX insulators and obtain the economy of permanently effective insulation.

PYREX INSULATORS

•"PYREX" is a Trade Mark and Indicates Manufacture by Corning Glass Works

3 LARGE TRANSFORMERS



60.000 K.V.A. 132 K.V.

60.000 K.V.A. 132 K.V.

800.00 K.V.A. 66 K.V.

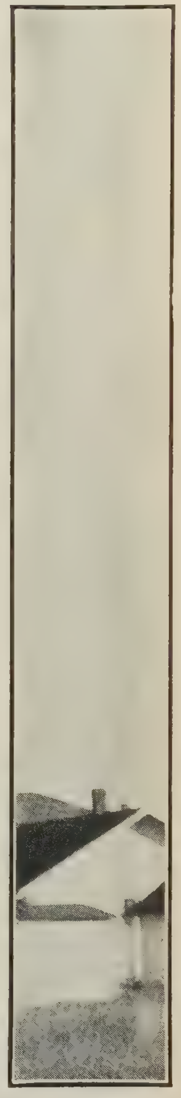
FERRANTI, Ltd.
26 Noble Street
Toronto

FERRANTI, Inc.
130 West 42d Street
New York

FERRANTI, Ltd.
Hollinwood
England

Burning! Shattering! Avoid with Correct Hardware!

Double plank trussed arm wishbone assembly on the Ft. Lupton-Greeley 110-kv. line of the Public Service Co. of Colorado.

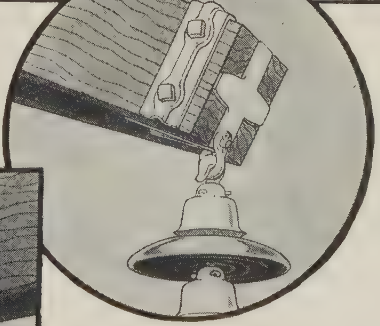


THE hardware fittings for wood cross-arms on high voltage lines may be, and often are the means for preventing burning and shattering of cross-arms and poles—damage, which otherwise often accompanies electrical disturbances on the line.

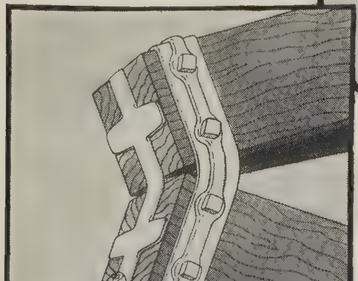
But, this effectiveness of the hardware is realized only if the design is adequate. The fittings must be of sizes and designs which will insure contacts of such low resistance that heat sufficient to burn the wood will not develop.

Large areas of metal in contact with the wood provide this low contact resistance in O-B hardware. In addition, the fittings permit the development of the full cross-arm strength, as well as aid materially in reducing or eliminating radio disturbance.

O-B cross-arm hardware fittings are provided for double plank H-frame or wishbone assembly, or for single beam cross-arms. These fittings are illustrated and discussed in a recently-issued publication on wood-pole construction. A copy of this publication — Bulletin 309-H — will be gladly sent upon request.



O-B cross-arm single end clamp for double plank arm, wishbone assembly.



O-B cross-arm double end clamp for double plank arm, wishbone assembly.

Ohio Brass Company, Mansfield, Ohio
Canadian Ohio Brass Co. Limited
Niagara Falls, Canada
1369H

Ohio Brass Co.

NEW YORK PITTSBURGH CHICAGO CLEVELAND ST. LOUIS ATLANTA DALLAS
PHILADELPHIA BOSTON LOS ANGELES SAN FRANCISCO SEATTLE

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

They've put *radio* on the force!

Now the officer gets his man with the aid of Western Electric radio telephone. In many a city the police department is equipping stations with this up to the minute apparatus.

Upon receiving a report of a burglary, the desk sergeant broadcasts it to police cars having radio receivers. This brings policemen to the scene in time to catch the criminal or while the clues are still fresh. In one city, between report and response the average time was 59 seconds.

Obviously for police purposes this apparatus must be reliable to an unusual degree. A product of the Western Electric workshop, it is made with all the skill and care that went into your Bell telephone. Here you have one more example of this Company's policy of applying its experience in *sound* to timely developments in the public's interest.

Western Electric

Makers of your Bell telephone and leaders in the development of sound transmission

The long arm of the law is made longer—
by Western Electric police radio.

All forged of copper-bearing steel Lapp Trunnion-Type Strain Clamp

WITH this new clamp it is now possible to have all hardware on the line of forged steel. Recognizing the advantages of forgings, Lapp has attempted to make Forged Steel available wherever possible. Starting with forged suspension insulator caps years ago, Lapp successively carried through the development of steel insulator fittings, not only of clevis design but of ball-and-socket as well; then the forged Trunnion-Type Suspension Clamp; and, now, Lapp All Forged Trunnion-Type Strain Clamp.

Required holding power is obtained by snubbing around a throat of liberal radius supported by a gently waved clamping seat that supplies good grip with minimum distortion to the conductor. An added feature of this clamping section is its slight taper which serves to increase the grip on the cable toward the jumper end.

The clamp is light in weight but very strong. Construction is simplified by forging the bolts integral with the keeper, reducing the number of parts to a minimum. Guide tips are provided on the bolts for easy catching of the thread. Lock washers used between serrated surfaces on nuts and clamp-body ears give a positive lock against nuts loosening under vibration.

Because of the reduced weight, together with the trunnion feature which greatly reduces the distance between the center of mass and the center of oscillation, the moment of inertia of this clamp is very low—1-10 to 1-15 that of the ordinary clamp. This means that the clamp will more nearly follow the vibrations of the conductor, and thereby greatly reduce the possibility of conductor breakage.

Send for Sample

LAPP INSULATOR CO. INC LAPP INSULATORS LE ROY - N.Y. - U.S.A.

"NORTH COAST LIMITED"

DEPENDS ON WESTON SPEED INDICATORS

ACROSS the Continental Divide, the "North Coast Limited," crack passenger train of the Northern Pacific Railway, meets and overcomes all operating conditions encountered in railroading. Despite varied weather conditions, it maintains dependable, safe, comfortable service for its thousands of passengers.

The "North Coast Limited," and other Northern Pacific cars and locomotives, are equipped with Weston Speed Indicators.

This use of Weston Tachometers by the Northern Pacific Railway typifies the dependable, accurate service that Weston equipment has given for years in the railway, marine, and industrial fields.

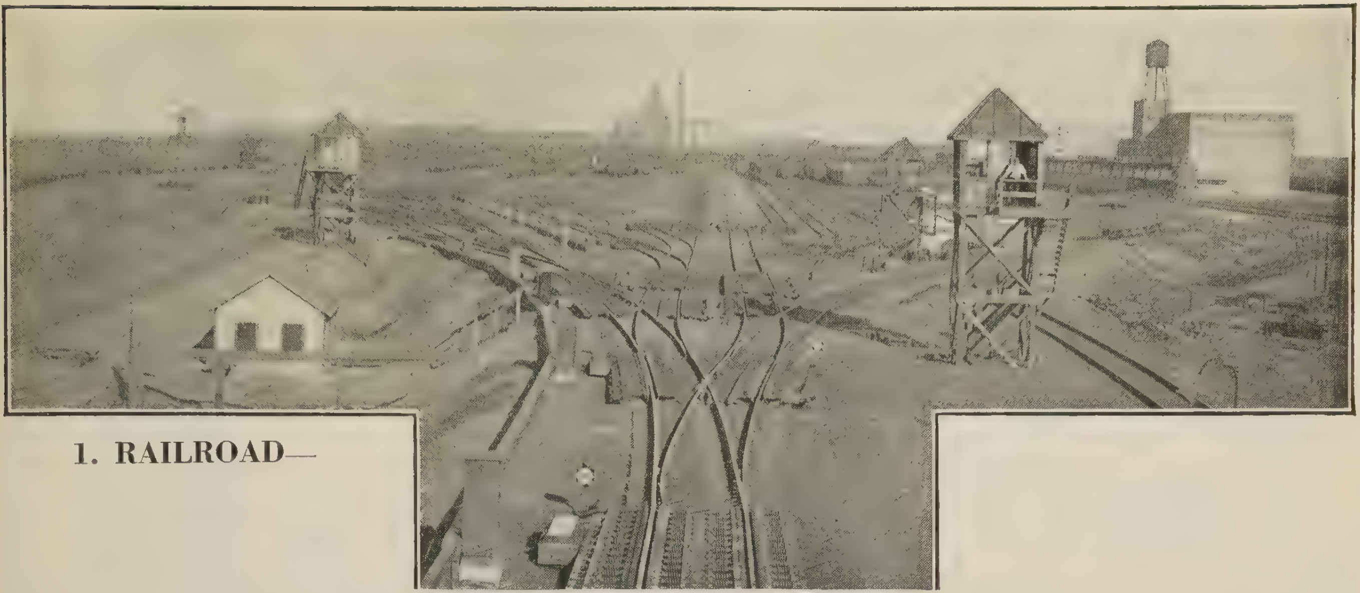
Features of Weston Tachometers have permitted the solution of many difficult and troublesome speed indication problems. We will gladly confer with you in the solution of your industrial tachometer problems.

Model 493 INDICATOR—as used on the "NORTH COAST LIMITED." Various type and size indicators are available for every purpose. Scales can be calibrated to suit requirements.

Model 44—Type C MAGNETO—as used on the "NORTH COAST LIMITED." Other sizes and types available to meet requirements of other applications. One or more Indicators, located where desired, may be used with the one magneto.

WESTON ELECTRICAL INSTRUMENT CORPORATION

584 Frelinghuysen Avenue — Newark, N. J.



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Proven Most Economical—In All Fields—

SHUNT WOUND

THE ELECTRIC PRODUCTS COMPANY

PATENTED

BATTERY CHARGER

THE DIVERTER POLE GENERATOR

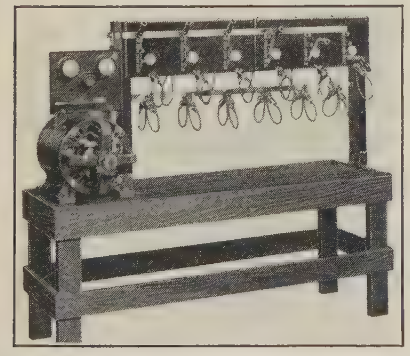
JAN. 1926

CONSTANT VOLTAGE INHERENT

CLEVELAND, OHIO, U.S.A.

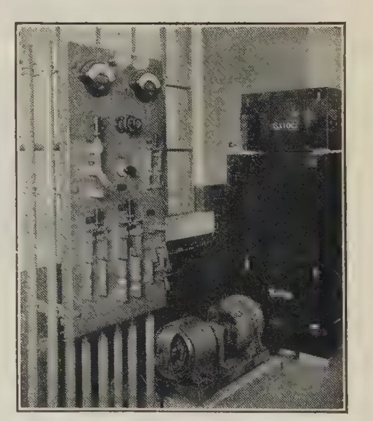
RUNS AS MOTOR SAFELY

For All Kinds of Battery Charging



2. AUTOMOTIVE—

3. TELEPHONE—



4. CENTRAL STATION—

Also Manufacturers of Low Voltage Electroplating Generators, variable speed D.C. Motors and Motor-Generators of all kinds.

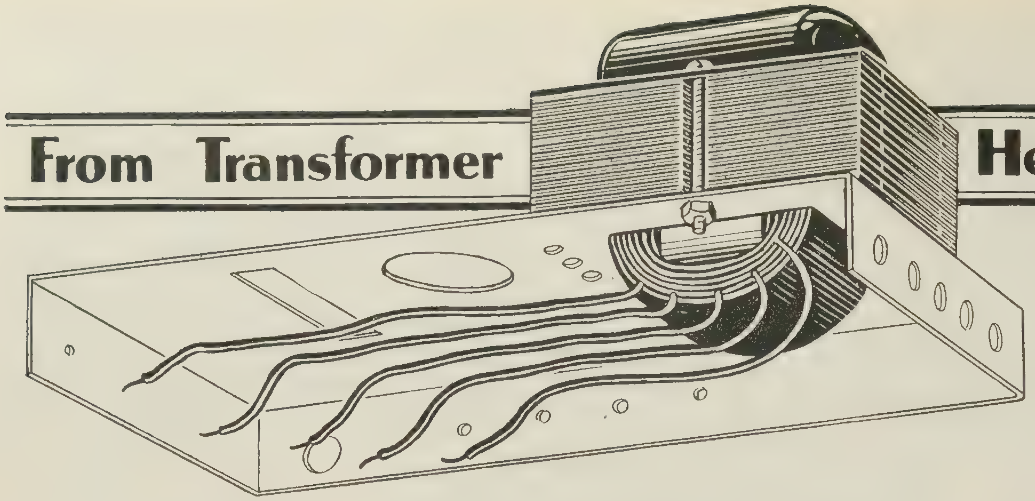
The Electric Products Co.

CLEVELAND, OHIO

1725 Clarkstone Road

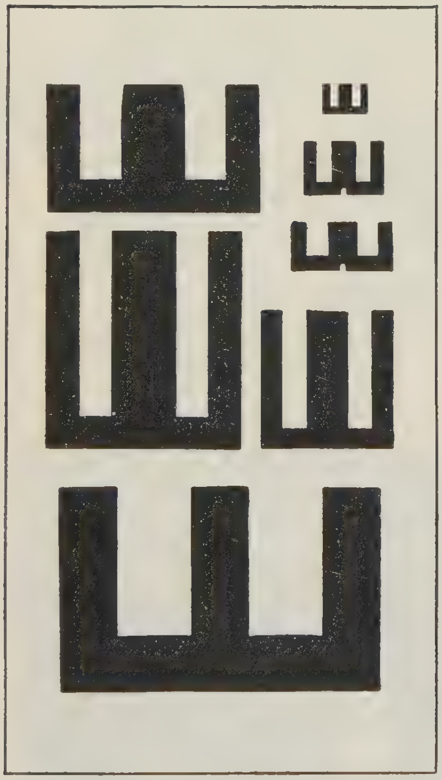
New York Office 126 Liberty St.

From Transformer Headquarters



This specialized transformer design provides very compact mounting and saves one end cover plate. The leads are connected directly to chassis parts, eliminating soldering to terminal lugs.

Laminations in Stock
All Types—All Sizes
For Any Transformer



Quick service to transformer users calls for two things:

1. A wide range of standard laminations to meet almost every need, and the facilities for making any special lamination design needed.
2. Ample facilities, such as automatic presses, winding machines, and impregnating equipment for assembling one or a thousand transformers to meet your specifications on short notice.

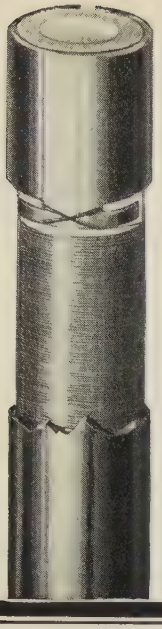
C. T. C. transformers are made entirely under one roof. Laminations, housings, coils, terminal blocks—every component part is a C. T. C. product.

Let C. T. C. engineers quote on your transformer requirements. Mail us your specifications today.

CTC

CHICAGO
TRANSFORMERS

CHICAGO TRANSFORMER CORP., 2624 WASHINGTON BLVD., CHICAGO, U. S. A.



PERMANENT ELECTRICAL CONTACTS and LOW CONTACT RESISTANCE are assured through this new Electrad Pressure Anchorage. Open ends permit air circulation throughout tube.

VITMONEL
FERRULE
TYPE

VITMONEL
STANDARD
LUG TYPE

WHY ELECTRAD

VITMONEL
VITREOUS RESISTORS

are

BETTER

PERMANENT contacts, accurate values, superior ventilation, proved service, moderate price. These are the factors which distinguish Electrad Resistors from the usual.

Electrad Ferrule Type Resistors for insertion in fuse clips offer many new features. Contact ferrules of Monel metal insure uniform expansion of all parts. Ferrules fit tightly by own spring pressure. Will not work loose under hardest usage. The resistance wire is permanently anchored to the ferrules by a new spring slot that lies flat under the enamel. No exposed wires or rough spots to corrode or cause trouble.

The usual center bolt being unnecessary, there is free circulation of air through the tube, assuring cooler operation. Standard ferrules 9/16″ and 11/16″ are available in all usual resistance values and wattage ratings for this type resistor. Special sizes to order. Standard lug type is also made in all usual sizes and special sizes to order.

A New Sound-Equipment Service

In the field of sound amplification, Electrad has taken a leading position. With a well-equipped plant and special laboratory, manned by amplifier and acoustical engineers of recognized reputation, your every need for large or small installations can be supplied.

Mail coupon for circular describing three standard models now ready for installation, complete with all accessories and expert counsel.

The Electrad line of resistors and voltage controls is *complete.* There is a unit for all radio purposes, small motor control, vacuum tube relays, counters and other devices.

Electrad engineers, specialists in the resistor field since the birth of radio, will gladly cooperate with you in the selection of the proper unit for your purpose—or if a special design is required, will develop it from your specifications.

Mail coupon for new, complete 36-page Electrad Catalog, containing all products and much valuable technical data.

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INC.

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Please send me data on ☐ Vitmonel Resistors.
☐ Sound Equipment. Complete Electrad Catalog.

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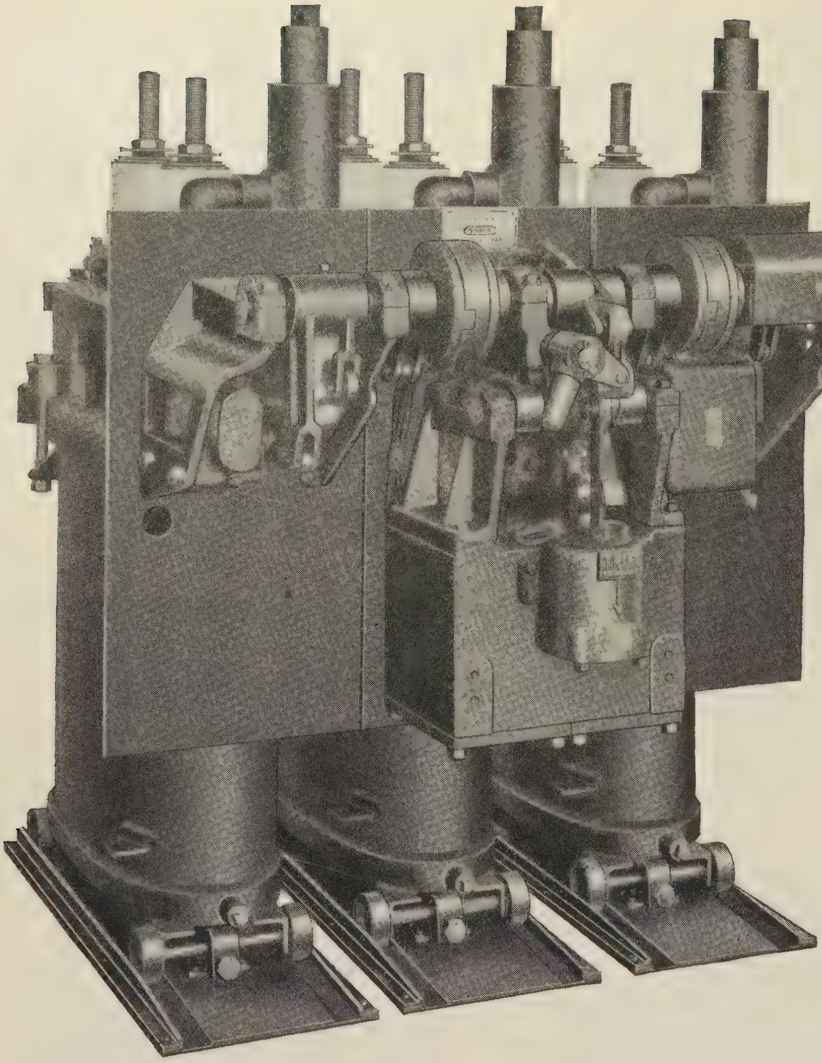
Address ....



F-110

●

ANY BREAKER WILL DO

until the trouble comes. Then the sturdy, quick-clearing Condit F-110 is the right breaker in the right place. You can depend on it because its dependability is built into it. Condit oil circuit breakers are tested in one of the outstanding electrical testing laboratories of the world, and their power of performance is known before they are released for service. Among other features contributing to its marked efficiency, the Condit F-110 has a magnetic blow-out, electro-magnetic accelerators, heavy arcing contacts of high thermal absorption capacity, instantaneous type mechanism, and oil and gas separators. The mechanism is enclosed, and there is a gasketed joint between the tank and the frame. Write for full information.

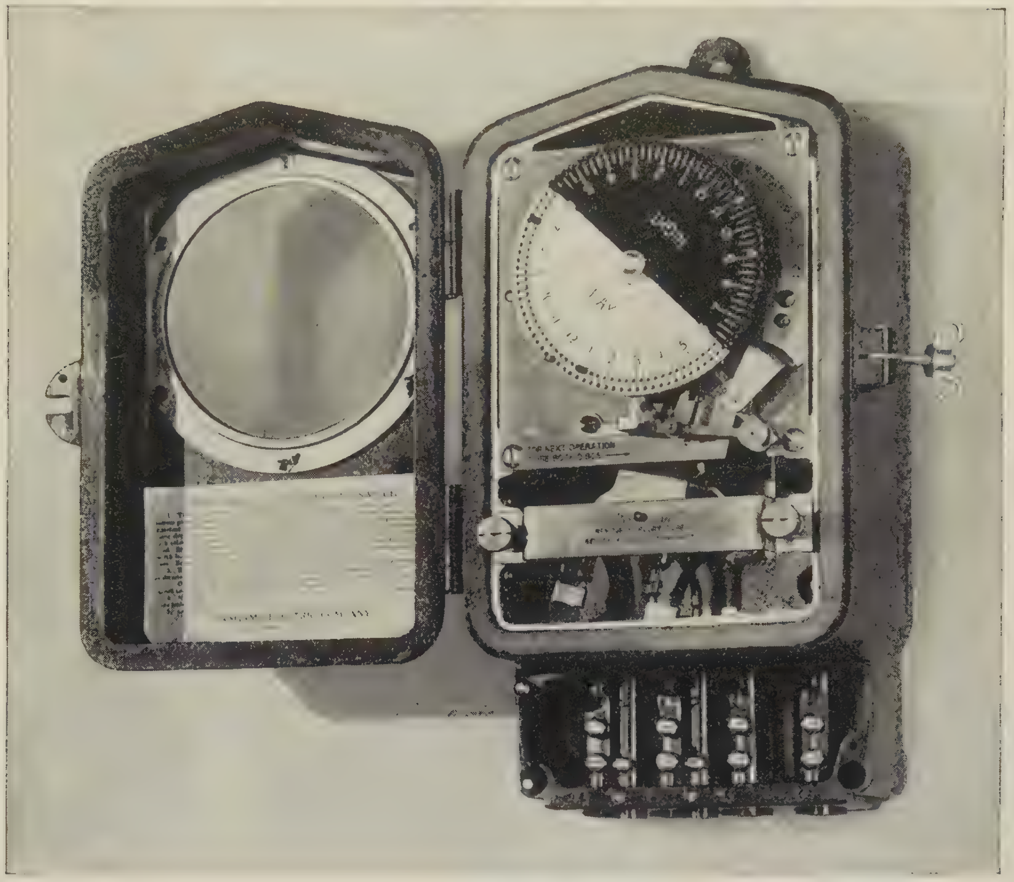
"Get in touch with Condit"

CONDIT ELECTRICAL MFG. CORPORATION

Boston, Massachusetts, U. S. A.

CONDIT

SANGAMO TIME-SWITCHES



ACCURATE TIME....ELECTRIC WINDING
MODERATE COST....LOW UPKEEP

The Sangamo Time-Switch is the product of combined facilities of two American manufacturers—each a leader in its field—Sangamo, makers of Meters, and Hamilton, manufacturer of the "Watch of Railroad Accuracy."

The Sangamo Time-Switch embodies these features:

1 . . . Accurate dependable time . . . insured by the standard Sangamo clock-movement with Hamilton 11-jewel escapement having a micrometer adjustment, and fully protected by dust-cap.

2 . . . Electric Winding . . . The switch mechanism is operated by a clock-mainspring, kept wound by a Sangamo motor which is continually in circuit. Because of ample reserve power, the switch is unaffected by current interruptions.

3 . . . Mercury tube contacts of latest design, shown by tests to be absolutely dependable in service.

4 . . . Independent of frequency or voltage variations.

5 . . . Made for either a. c. or d. c. operation.

6 . . . Low maintenance cost . . . simple, sturdy design assures trouble-free operation. All parts interchangeable.

For medium-priced installations as well as costly ones, wherever a sturdy and thoroughly dependable time-switch is required . . . specify Sangamo. Available with meter terminal base or conduit-connected base.

Write for descriptive folder giving complete details.

SANGAMO ELECTRIC COMPANY • SPRINGFIELD, ILLINOIS

Four reasons for using

SIMPLEX

Non-Metallic Underground Cable

Simplex Non-Metallic Underground Cable is made in two types, type W P protected by a series of weatherproofed tapes, and type R J protected by a rubber jacket and weatherproofed tapes.

In addition to the comparatively low cost and dependability of Simplex Underground Cable with non-metallic protection these other features make it a most practical and efficient cable.

CONDUIT UNNECESSARY

The cable may be laid directly in the ground without conduit, thereby materially reducing installation costs.

LIGHT WEIGHT

The elimination of metallic protection results in a cable of less weight and makes shipping and handling charges lower.

ADEQUATE PROTECTION

The tough, long-wearing sheaths of Simplex Underground Cable furnish ample protection against acid, alkali and moisture. Being non-metallic they will not rust.

EASE OF INSTALLATION

Because it is light and flexible, workmen have no trouble in handling and quickly laying this cable. Unskilled labor may be used. It is easy to splice.

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PHILADELPHIA, 1227 Fidelity-Philadelphia Trust Building
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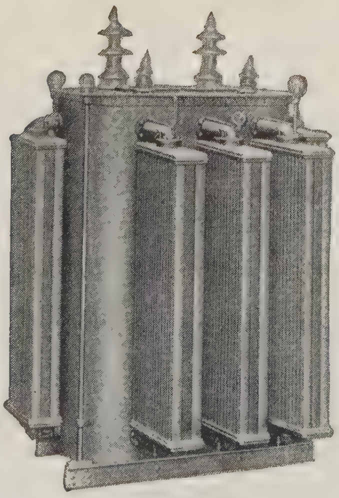
SIMPLEX INSULATED WIRES & CABLES

MOLONEY



Satisfactory Service

Under all conditions and in any service—that's the guarantee you get with Moloney Quality—it's the reason Moloney Transformers are being used more and more by both large and small power and light companies throughout the country.

MOLONEY ELECTRIC COMPANY
Main Office and Factories: ST. LOUIS, MO.
Sales Offices in Principal Cities

TRANSFORMERS

ROEBLING

NO MATTER what your electrical wire or cable requirements may be—whether for Rubber Covered Code, Parkway Cable, or even hair-fine magnet wire for winding coils—they can be satisfied by the Roebling Line.

Electric light and power companies, industrial electrical maintenance departments and others will find every type of electrical wire and cable in the comprehensive Roebling Line to be of the very highest quality. Roebling has been making these products for over 45 years and has always adhered to most exacting standards.

Roebling is geared up to provide prompt service. Sales representatives and stocks of many types of wires and cables are located in the cities listed below.

Power Cables · Paper; Cambric; Rubber » Submarine Cables » Tree Wire » Parkway Cable » Service Cables » Station Cables » Rubber Covered Control Cables » Rubber Covered Wires and Cables · Braided and Leaded · Code: Intermediate; 30% » Slow-burning Wires and Cables » Weatherproof Wires and Cables » Portable Cords » And a wide variety of other wires and cables.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N. J.
Atlanta Boston Chicago Cleveland Los Angeles
New York Philadelphia Portland, Ore. San Francisco Seattle
Export Dept., New York, N. Y.

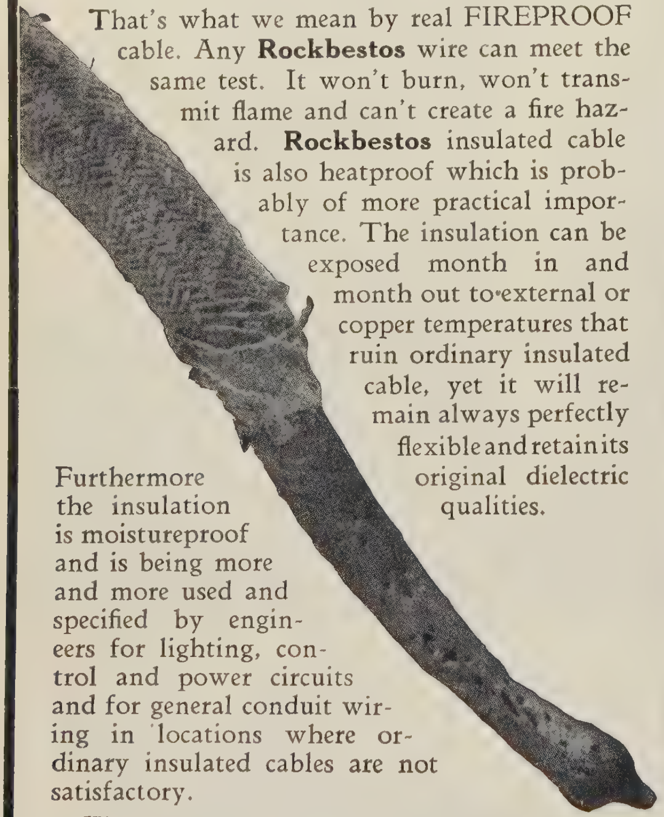
ELECTRICAL WIRES AND CABLES

Copper Heating can't harm *this* Cable Insulation

HERE'S an unretouched photograph of a section of 300,000 C. M. motor lead cable which was exposed to an exaggerated case of copper heating—the conductor melted! But being a **Rockbestos** motor lead, the insulation didn't burn, didn't transmit fire and even after the conductor had melted, had considerable mechanical and dielectric strength.

That's what we mean by real FIREPROOF cable. Any **Rockbestos** wire can meet the same test. It won't burn, won't transmit flame and can't create a fire hazard. **Rockbestos** insulated cable is also heatproof which is probably of more practical importance. The insulation can be exposed month in and month out to external or copper temperatures that ruin ordinary insulated cable, yet it will remain always perfectly flexible and retain its original dielectric qualities.

Furthermore the insulation is moistureproof and is being more and more used and specified by engineers for lighting, control and power circuits and for general conduit wiring in locations where ordinary insulated cables are not satisfactory.



We would like to place in the hands of interested engineers samples of **Rockbestos** motor lead cable and other wires with permanent insulation. Simply use the convenient coupon. There's no obligation.

ROCKBESTOS PRODUCTS
CORPORATION
384 NICOLL ST. NEW HAVEN, CONN.

Yes, please send me at no obligation, the samples you mention.

Name..........

Company..........

Address..........

ROCKBESTOS—*the wire with permanent insulation*

MINERALLAC STATISCOPES

Safety devices for the protection of the Electrical Worker

(The Pocket Type)

POCKET TYPE

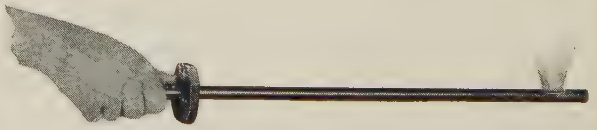
Intended for all-round testing where a sensitive instrument is desired. Especially adapted for use on underground cable work. 2000 Volts and Up.

STATION TYPE

For use in Stations and Substations and on outdoor high-voltage equipment.

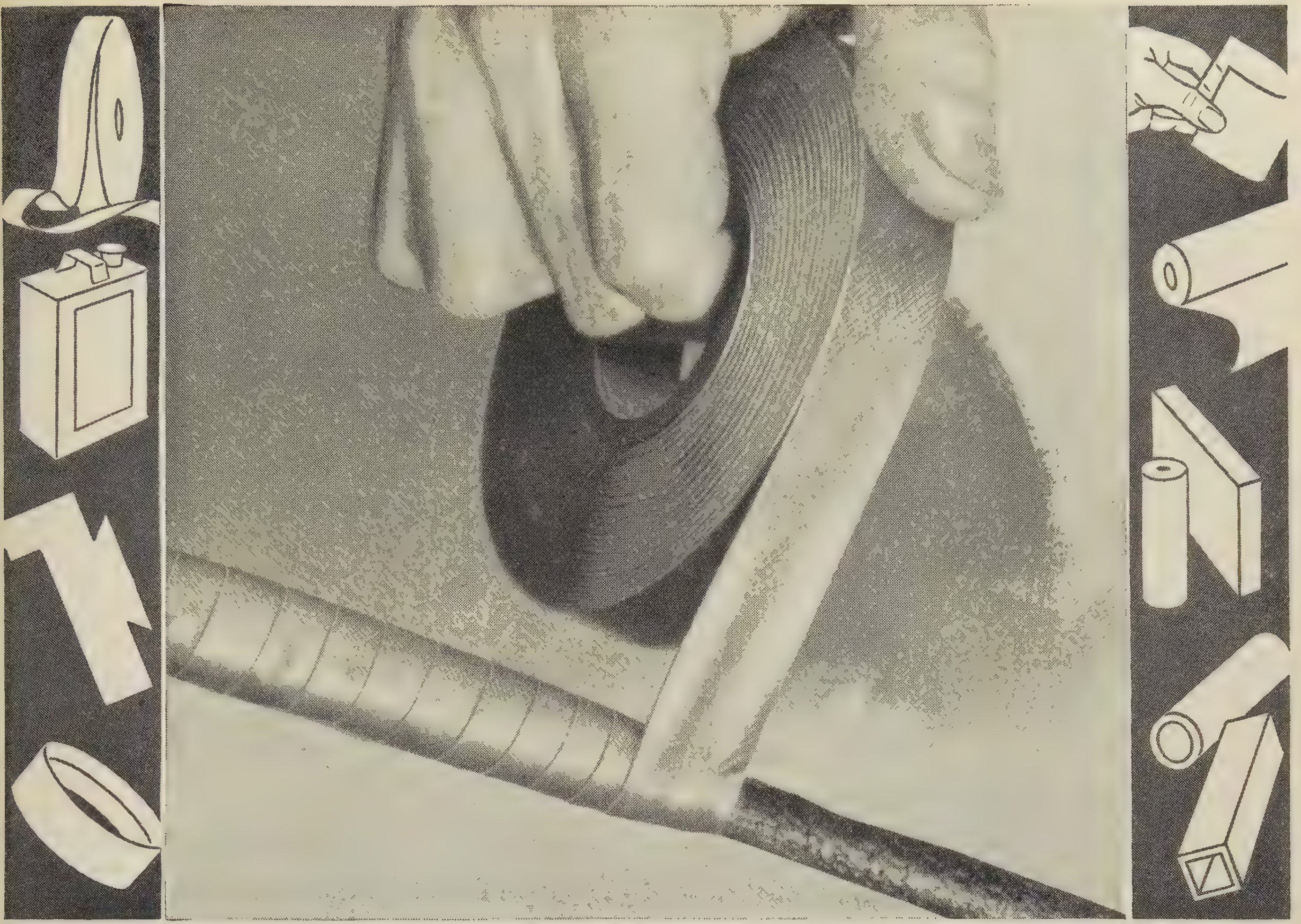
Designed to give indication of Alternating Current potentials of 2000 Volts and up.

Exact length 24 inches.



(The Station Type)

MINERALLAC
ELECTRIC COMPANY
25 North Peoria St. Chicago, Ill.



Insulate with Empire Tape

for positive protection

GREAT dielectric and mechanical strength are combined in this varnished cambric tape. It's seamless, bias cut and made in long continuous lengths. For wrapping cable joints, coils and other conductors, manufacturers and repairmen have found it an ideal tape.

It's one of the some hundred electrical insulations with which the Mica Insulator Company fills the needs of industry. One characteristic is common to all these insulations—a uniform, unsurpassed quality —which is the result of more than 37 years of specialization.

The Mica Insulator Company provides an electrical insulation for every purpose. Catalog 87 gives the characteristics and suggested uses, in detail. Send for a copy.

MICA INSULATOR COMPANY
New York: 200 Varick St. Chicago: 542 So. Dearborn St.
Cleveland Pittsburgh Cincinnati San Francisco Seattle
Birmingham Los Angeles Montreal and Toronto, Canada
Works: Schenectady, N. Y. London, England

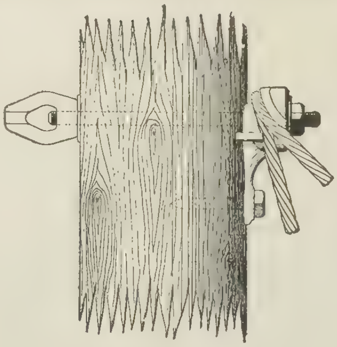
MICA INSULATOR COMPANY

Electrical Insulations

PERFECT LAMICOID REG. U. S. PAT. OFF.
PERFECT MICANITE INSULATOR REG. U.S. PAT. OFF.
PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF.
PERFECT MICO INSULATIONS

A COMPLETE LINE FOR EVERY PURPOSE

New Data on Guying



P129 Eye Nut—P132 Guy Hook

New Sales Bulletin No. 5, now available, suggests improved specifications for stub and anchor guying, etc., based on the proven performance of our patented P132 Guy Hook, the original design illustrated. This Guy Hook is for use with ¾″ and 1″ through-bolts, and for guy strand up to 5/8″, incl.

The P133 Guy Hook is similar but smaller throughout, and develops the full strength of 5/8″ through-bolt with strands up to 7/16″, incl., using supporting lag as illustrated. These Guy Hooks have been widely standardized as the preferred method of through-bolt guying. Bulletin No. 5 also features use of accessory Eye Nuts, Double Guying Blocks, Heavy Duty Guy Clamps, Shull Boltless Guy Clamps, Pick-up Head Anchor Rods, Curved Ribbed Washers, also standard Guy Strain Plates, J-Hooks, etc.

Send for Sales Bulletin No. 5.

Trial orders may be placed at these prices, F. O. B. Branford, Conn.

P132......$31.00 per hundred. P133......$17.00 per hundred.

Other M. I. F. Pole Hardware Specialties include: Williams Pole Mounts, Crossarm Gains, Aerial Cable Suspension Clamps, Insulated Suspension Hangers, Reinforcing and Extension Clamps for tubular steel poles, etc. Send for Bulletins on items of interest.

We feature Engineering Service for special applications

MALLEABLE IRON FITTINGS COMPANY

Pole Hardware Dept. [Factory and New England Sales Office] **Branford, Connecticut**

New York Sales Office: Thirty Church Street

Canadian Mfg. Distributor:

LINE & CABLE ACCESSORIES, Ltd., Toronto

"COPPERWELD" Ground Rods Are Easily Driven

Copperweld Ground Rods are made by welding molten copper to a core of electric furnace steel.

The stiff steel core of every Copperweld Ground Rod makes the rod rigid and easy to drive.

The thick copper exterior of Copperweld Ground Rods prevents them from rusting and gives a copper-to-copper connection with the grounding lead.

The Copperweld Grounding Clamp is quickly connected and may be readily re-connected after measuring the ground resistance.

Copperweld Steel Company

Glassport, Penna.

WE STOCK FOR YOU

EVERDUR BOLTS

STRONGER THAN STEEL

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EVERY BOLT STAMPED AND DATED

CORROSION FREE

•

MILLIONS NOW IN SERVICE

BOLTS, U-BOLTS, NUTS, WASHERS, LOCKWASHERS and SCREWS

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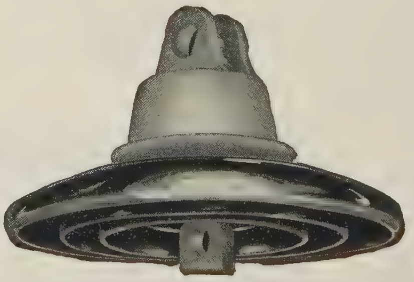

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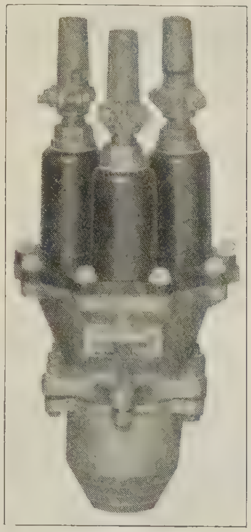

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The space saving so important in station construction is accomplished by the use of a molded cover employing material closely approaching porcelain in its electrical properties and mechanically stronger.

Designed for either oil or compound filling, they are vacuum-tight and will withstand a hot oil pressure of 50 pounds per square inch with oil at 180° F.

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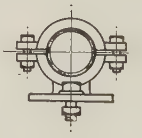
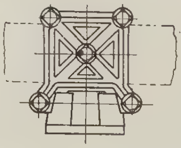
Type "A" Constant Contact Clamp. Dependable for even distribution of pressure at joints or tap-offs on all ordinary sizes of bus bar.



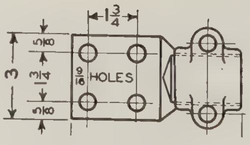
TYPE RP



TYPE AS

Type "RP" — for round bus tubing from ½ inch to 2 inches. Type "AS" — for vertical bus bar. Type "AT" — for horizontal bus bar.

Interchangeable unit Bus Support. Three inch bolt circle and 90 degree adjustable clamps.



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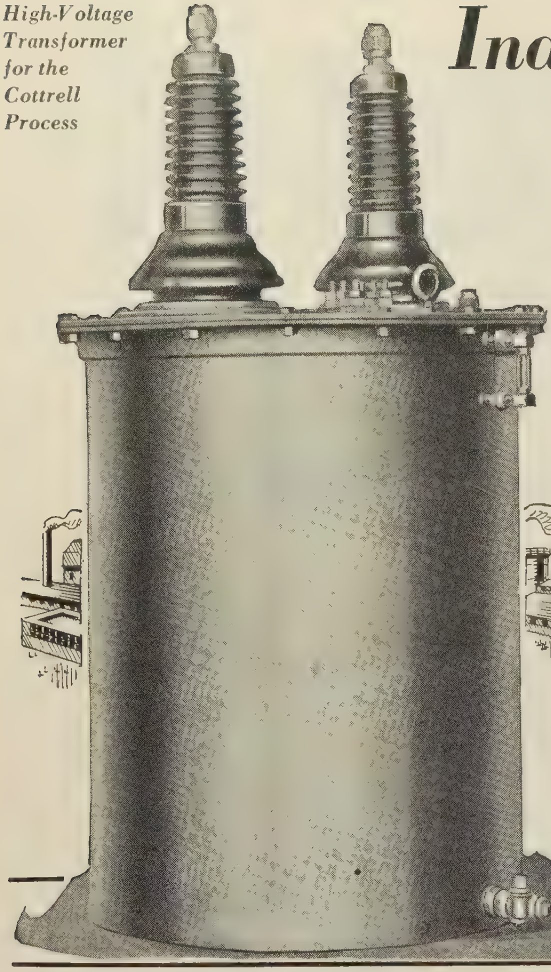

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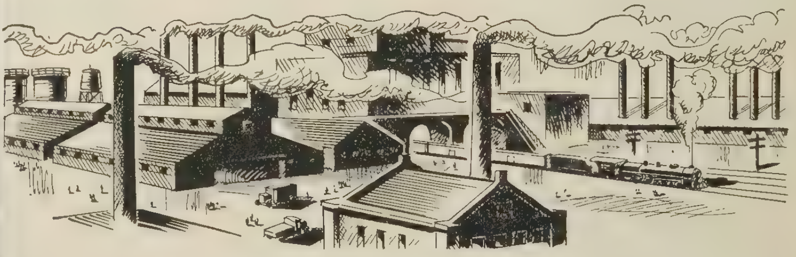

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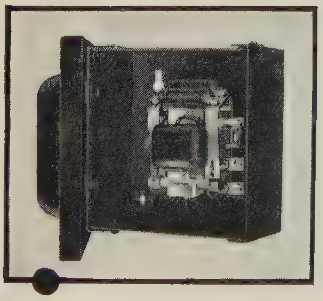

Ward Leonard Relay Mounted in Pressed Steel Box Provided with Mounting Holes and for Conduit Connections.

IN selecting equipment to meet the requirements of automatic or remote control problems, the critical buyer demands relays which will "more than do the job." Often satisfactory performance over a period of years depends just as much upon details of construction as upon correct basic design. And to Ward Leonard, the manufacture of relays is much more than a matter of efficient basic design.

Perfection of detail is the added factor in Ward Leonard relays. Listed among the 14 standard features in Bulletin 81,000 are the fine points of design and construction which satisfy every requirement of the critical buyer.

Send for a copy of this bulletin today. It describes in detail Ward Leonard Magnetic Relays for A. C. and D. C., methods of mounting, and methods of control.

Specially Designed Coils Used in All Ward Leonard Relays Keep Watts Loss to a Minimum, thereby Conserving Valuable Power. Below:—Ward Leonard Relay Mounted on Cast Aluminum Base with Cast Aluminum Cover.

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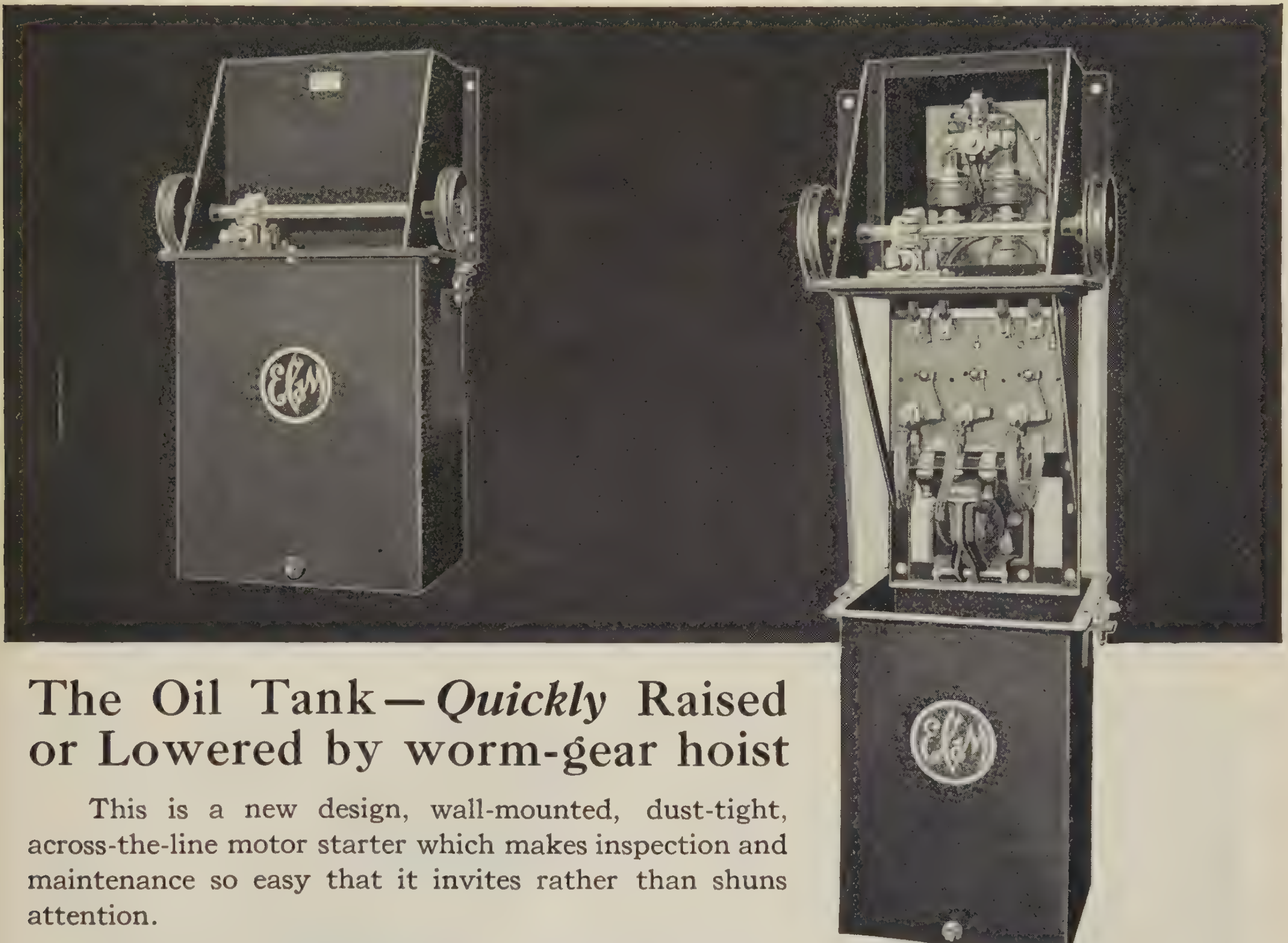
WARD LEONARD MAGNETIC RELAYS

A Heavy Duty Motor Starter
Built for Ease of Maintenance



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This is a new design, wall-mounted, dust-tight, across-the-line motor starter which makes inspection and maintenance so easy that it invites rather than shuns attention.

Each starter is equipped with a self-contained worm-gear hoist operated by a removable crank handle which permits quickly lowering the oil tank for inspection and then quickly hoisting it back to its normal position so that operation can be continued with minimum interruption.

The worm-gear is self-locking and holds the tank in any desired position. For additional protection when the tank is in the raised position, five bolts are provided to bolt it to the supporting frame.

Due to the oil-immersed and dust-tight construction, this starter may be used in any dusty corrosive or explosive atmosphere with perfect safety. Specification Sheet S-32, just off the press, gives a complete description. Write for a copy.

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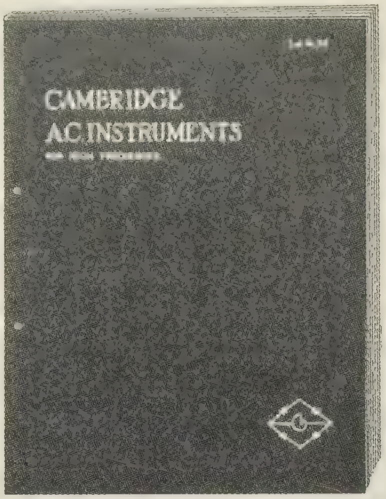

LIST 162-E describes instruments designed for the measurement of constants of high frequency circuits, and suitable for use either upon the commercial tests required by the electrical engineer or in the research laboratory.

A technical supplement to this List detailing methods of test and measurement with accompanying diagrams may also be obtained upon request.

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It is recommended particularly for radio testing.
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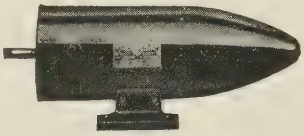

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are extremely useful pieces of equipment for the laboratory engaged in research, development, and tests on electrical equipment. They are the best means of obtaining large values of capacitance because they are adjustable, are reasonably stable in calibration, have low energy losses, and are low in price. When used in parallel with a small variable air condenser, one of the larger sizes will give any desired capacitance between a few micromicrofarads and 1.1 microfarads.

One size is shown here. Others are described in Catalog F-J4, a copy of which will be mailed on request.

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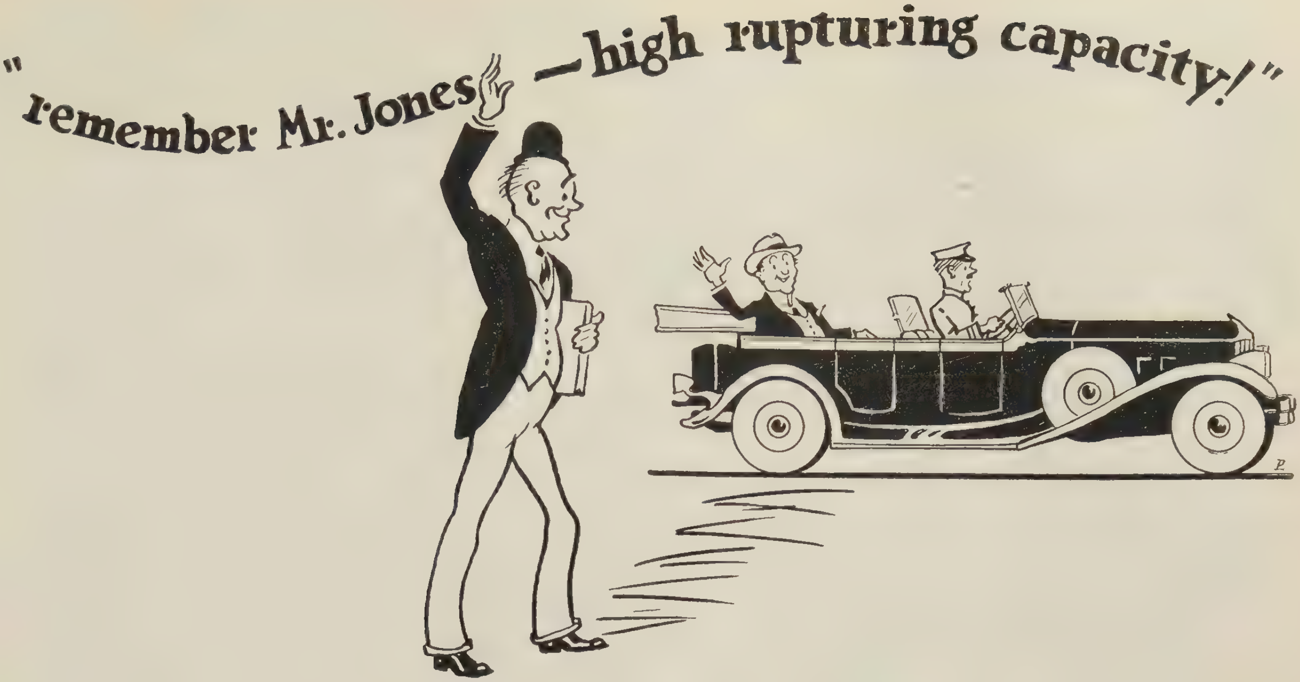
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P.S.—And don't forget—U-RE-LITE belongs to a large and powerful family capable of taking care of any and every circuit from 1600 amperes down to ½ ampere.

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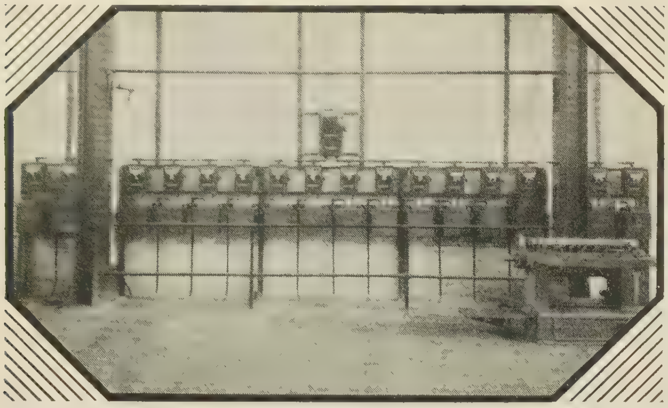

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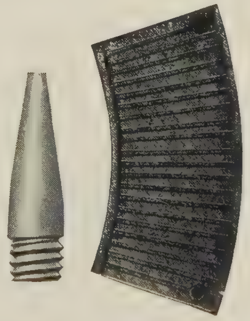

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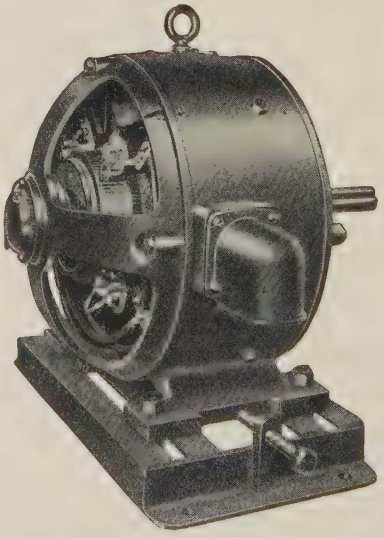

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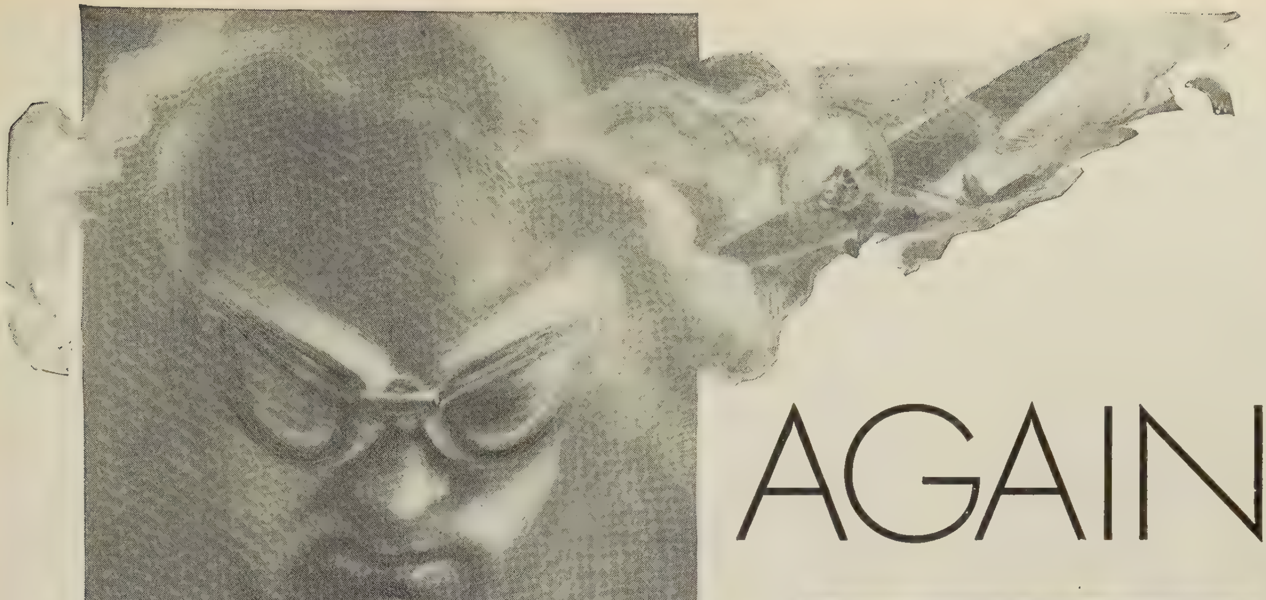

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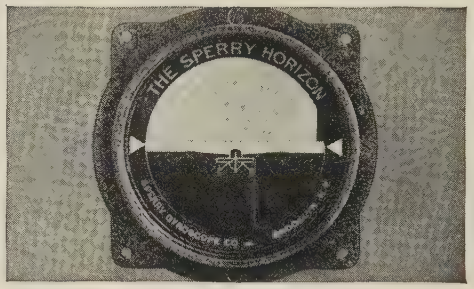

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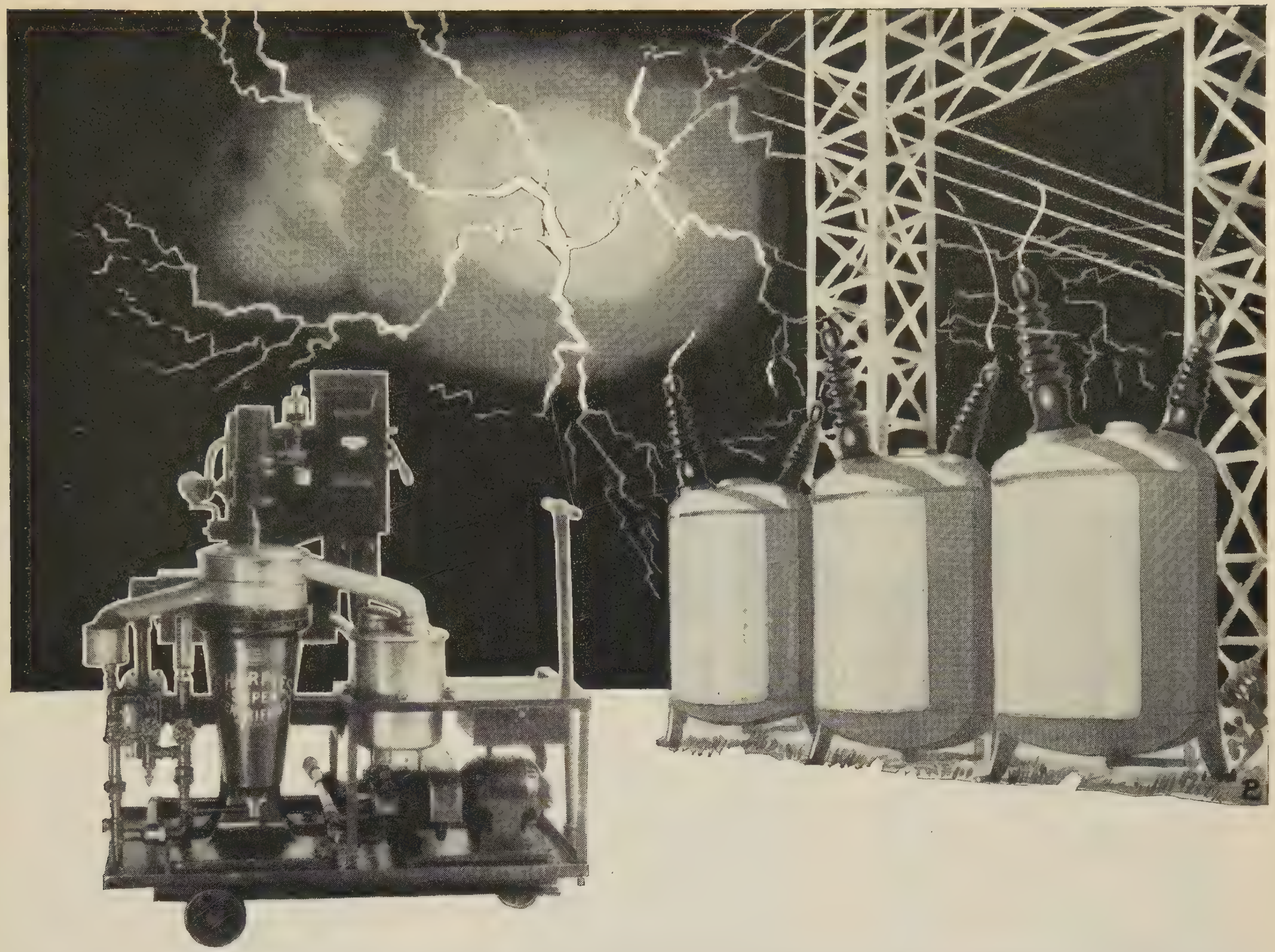

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Oil
Condit Electrical Mfg. Corp., Boston
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CLAMPS, GUY & CABLE
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Kearney Corp., Jas. R., St. Louis
Malleable Iron Fittings Co., Branford, Conn.
Railway Ind. & Engg. Co., Greensburg, Pa.

CLAMPS, INSULATOR
Champion Switch Co., Kenova, West Va.
Delta-Star Electric Co., Chicago
Memco Engg. & Mfg. Co., L. I. City, N. Y.

COILS, CHOKE
American Transformer Co., Newark, N. J.
Burke Electric Co., Erie, Pa.
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COILS, MAGNET
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COMMUTATOR SEGMENTS AND RINGS
Mica Insulator Co., New York

CONDENSERS, RADIO
General Radio Co., Cambridge, Mass.

CONDENSERS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONDUIT, UNDERGROUND FIBRE
Western Electric Co., All Principal Cities

CONNECTORS SOLDERLESS
Burke Electric Co., Erie, Pa.
Delta-Star Electric Co., Chicago
Dossert & Co., New York
Kearney Corp., Jas. R., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONNECTORS AND TERMINALS
Belden Mfg. Co., Chicago
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Champion Switch Co., Kenova, West Va.
Delta-Star Electric Co., Chicago
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
Railway & Ind. Engg. Co., Greensburg, Pa.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONTACTS, TUNGSTEN
General Electric Co., Schenectady

CONTROL SYSTEMS
Ward Leonard Electric Co., Mt. Vernon, N. Y.

CONTROLLERS
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Rowan Controller Co., Baltimore, Md.
Ward Leonard Electric Co., Mt. Vernon, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONVERTERS—SYNCHRONOUS
Allis-Chalmers Mfg. Co., Milwaukee
Electric Specialty Co., Stamford, Conn.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COPPER CLAD WIRE
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities

COPPERWELD WIRE
Copperweld Steel Co., Glassport, Pa.

CUT-OUTS
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., S. Boston
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
G & W Electric Specialty Co., Chicago
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

DIMMERS, THEATRE
Ward Leonard Electric Co., Mt. Vernon, N. Y.

DIVERTER POLE GENERATORS
Electric Products Co., Cleveland, O.

DYNAMOS
(See GENERATORS AND MOTORS)

DYNAMOTORS
Burke Electric Co., Erie, Pa.
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

ELECTRIFICATION SUPPLIES, STEAM ROAD
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, Ohio
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ENGINEERS, CONSULTING AND CONTRACTING
(See PROFESSIONAL ENGINEERING DIRECTORY)

ENGINES
Gas & Gasoline
Allis-Chalmers Mfg. Co., Milwaukee
Oil
Allis-Chalmers Mfg. Co., Milwaukee
Steam
Allis-Chalmers Mfg. Co., Milwaukee

EXPERIMENTAL WORK
Manufacturers' and Inventors' Electric Co., New York

FANS, MOTOR
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FLOW METERS
General Electric Co., Schenectady

FURNACES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FUSES
Enclosed Refillable
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Enclosed Non-Refillable
General Electric Co., Schenectady
Open Link
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
High-Tension
Metropolitan Device Corp., Brooklyn, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.

FUSE MOUNTINGS
Delta-Star Electric Co., Chicago
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.

FUSE PULLERS
Kearney Corp., Jas. R., St. Louis

GEARS, FIBRE
General Electric Co., Schenectady

GENERATORS AND MOTORS
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
Chandeysson Electric Co., St. Louis
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.
Electro-Dynamic Co., Bayonne, N. J.
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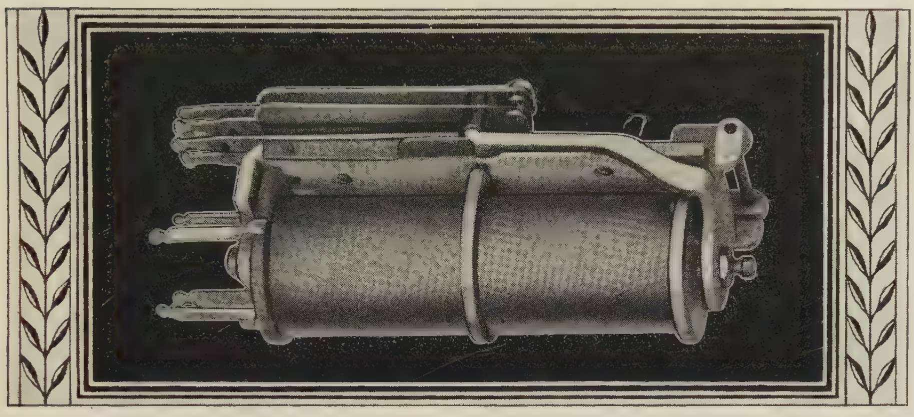

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GENERATING STATION EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Copperweld Steel Co., Glassport, Pa.
Metropolitan Device Corp., Brooklyn, N. Y.

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General Electric Co., Bridgeport, Conn.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

HEADLIGHTS
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

HEATERS, INDUSTRIAL
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INDICATORS, SPEED
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

INSTRUMENTS, ELECTRICAL
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Cambridge Instrument Co., New York
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Indicating
Cambridge Instrument Co., New York
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Sangamo Electric Company, Springfield, Ill.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.
Integrating
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Sangamo Electric Company, Springfield, Ill.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Radio
Cambridge Instrument Co., New York
General Radio Co., Cambridge, Mass.
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.
Repairing and Testing
Cambridge Instrument Co., New York
Electrical Testing Laboratories, New York
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.
Scientific, Laboratory, Testing
Cambridge Instrument Co., New York
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.

INSULATING MATERIALS
Board
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York
Cloth
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Composition
American Lava Corp., Chattanooga
General Electric Co., Bridgeport, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Compounds
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Fibre
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York
Lava
American Lava Corp., Chattanooga, Tenn.

INSULATING MATERIALS—*Continued*
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Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Paper
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Silk
General Electric Co., Bridgeport, Conn.
Tape
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Okonite Co., The, Passaic, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Varnishes
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATORS, HIGH TENSION
Composition
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Glass
Corning Glass Works, "PYREX," Corning, N. Y.
Hemingray Glass Co., Muncie, Ind.
Porcelain
Canadian Porcelain Co., Ltd., Hamilton, Ont.
Champion Switch Co., Kenova, West Va.
General Electric Co., Schenectady
Lapp Insulator Co., Inc., LeRoy, N. Y.
Locke Insulator Corp., Baltimore
Ohio Brass Co., Mansfield, O.
Thomas & Sons Co., R., Lisbon, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Post Type
Delta-Star Electric Co., Chicago
Ohio Brass Co., Mansfield, O.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATORS, TELEPHONE & TELEGRAPH
Hemingray Glass Co., Muncie, Ind.
Ohio Brass Co., Mansfield, O.

INSULATOR PINS
Ohio Brass Co., Mansfield, O.
Thomas & Sons, Co., R., Lisbon, O.

LADDERS, TRUCK
Metropolitan Device Corp., Brooklyn, N. Y.

LAVA
American Lava Corp., Chattanooga

LIGHTNING ARRESTERS
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

LOCOMOTIVES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

LUBRICANTS
Texas Company, The, New York

MAGNETIC SEPARATORS
Electric Controller & Mfg. Co., Cleveland

METERS, ELECTRICAL
(See INSTRUMENTS ELECTRICAL)

METER SEALS
Metropolitan Device Corp., Brooklyn, N. Y.

MICA PRODUCTS
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MOLDED INSULATION
Burke Electric Co., Erie, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MOTORS
(See GENERATORS AND MOTORS)

OHMMETERS
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

OIL SEPARATORS & PURIFIERS
Sharples Specialty Co., The, Philadelphia
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

OIL TESTING SETS
American Transformer Co., Newark, N. J.

PANEL BOARDS
(See SWITCHBOARDS)

PATENT ATTORNEYS
(See PROFESSIONAL ENGINEERING DIRECTORY)

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Burke Electric Co., Erie, Pa.
Chandeysson Electric Co., St. Louis
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

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Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Malleable Iron Fittings Co., Branford, Conn.

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General Electric Co., Bridgeport, Conn.
Ohio Brass Co., Mansfield, O.

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G & W Electric Specialty Co., Chicago
Ohio Brass Co., Mansfield, O.
Railway & Ind. Engg. Co., Greensburg, Pa.

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Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

REACTORS
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Metropolitan Device Corp., Brooklyn, N. Y.

RECTIFIERS
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Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roller-Smith Co., New York
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.

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Electrad, Inc., New York
Ward Leonard Electric Co., Mt. Vernon, N. Y.

RESISTOR UNITS
Electrad, Inc., New York
General Electric Co., Schenectady
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

RHEOSTATS
General Electric Co., Schenectady
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.

SEARCHLIGHTS
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SLEEVE TWISTERS
Kearney Corp., Jas. R., St. Louis

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Memco Engg. & Mfg. Co., L. I. City, N. Y.

SOCKETS AND RECEPTACLES
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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Roller-Smith Co., New York
Ward Leonard Electric Co., Mt. Vernon, N. Y.
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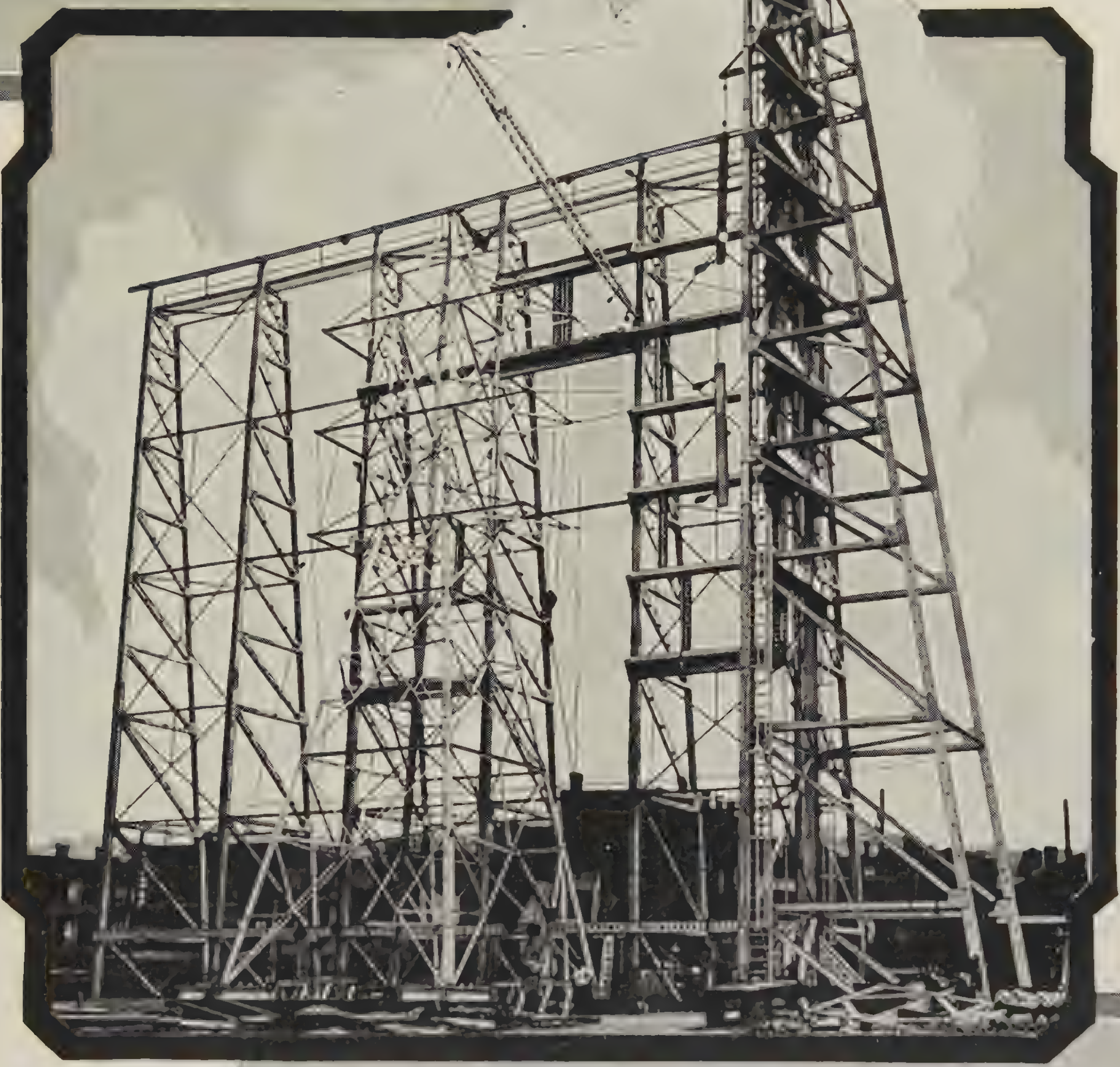

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Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Ward Leonard Electric Co., Mt. Vernon, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

STOKERS, MECHANICAL
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SUB-STATIONS
American Bridge Co., New York
Champion Switch Co., Kenova, West Va.
General Electric Co., Schenectady
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHBOARDS
Allis-Chalmers Mfg. Co., Milwaukee
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHES

Automatic Time
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Disconnecting
Bull Dog Electric Products Co., Detroit
Burke Electric Co., Erie, Pa.
Champion Switch Co., Kenova, West Va.
Condit Electrical Mfg. Corp., Boston
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Fuse
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.

Knife
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Magnetic
Electric Controller & Mfg. Co., Cleveland
Ward Leonard Electric Co., Mt. Vernon, N. Y.

Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Remote Control
Automatic Electric, Inc., Chicago
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co.. E. Pittsburgh

TELEPHONE CONNECTORS
Kearney Corp., Jas. R., St. Louis

TELEPHONE & SIGNALING SYSTEMS
Automatic Electric, Inc., Chicago

TERMINAL BLOCKS
Burke Electric Co., Erie, Pa.

TERMINATORS
Delta-Star Electric Co., Chicago

TESTING LABORATORIES
Electrical Testing Labs., New York

TESTING SETS, HIGH VOLTAGE
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady

TOWERS, TRANSMISSION
American Bridge Co., New York

TRANSFORMERS
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago

TRANSFORMERS—*Continued*
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Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Sangamo Electric Company, Springfield, Ill.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Factory
American Transformer Co., Newark, N. J.
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis, Mo.
Wagner Electric Corp., St. Louis

Furnace
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Metering
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Company, Springfield, Ill.
Weston Elec. Inst. Corp., Newark, N. J.

Radio
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Sangamo Electric Company, Springfield, Ill.

Street Lighting
Kuhlman Electric Co., Bay City, Mich.

TROLLEY LINE MATERIALS
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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINE GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBO-GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

VALVES, BRASS

Gas, Water, Steam
Ohio Brass Co., Mansfield, O.

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General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING MACHINES, ELECTRIC
American Transformer Co., Newark, N. J.
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING WIRES & RODS
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

WIRES AND CABLES

Aluminum and A. C. S. R.
Aluminum Co. of America, Pittsburgh

Armored Cable
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

WIRES AND CABLES—*Continued*

Asbestos Covered
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.

Asbestos, Varnished Cambric
Rockbestos Products Corp., New Haven, Conn.

Automotive
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

Bare Copper
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Copper Clad
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities

Copperweld
Copperweld Steel Co., Glassport, Pa.

Flexible Cord
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston

Flexible Cord, (Heater) Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Heavy Duty Cord
American Steel & Wire Co., Chicago
Okonite Company, The, Passaic, N. J.
Simplex Wire & Cable Co., Boston

Fuse
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.

Lead Covered (Paper and Varnished Cambric Insulated)
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

Leads, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Magnet
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Magnet, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Rubber Insulated
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

Switchboard, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Tree Wire
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston

Trolley
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Weatherproof
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
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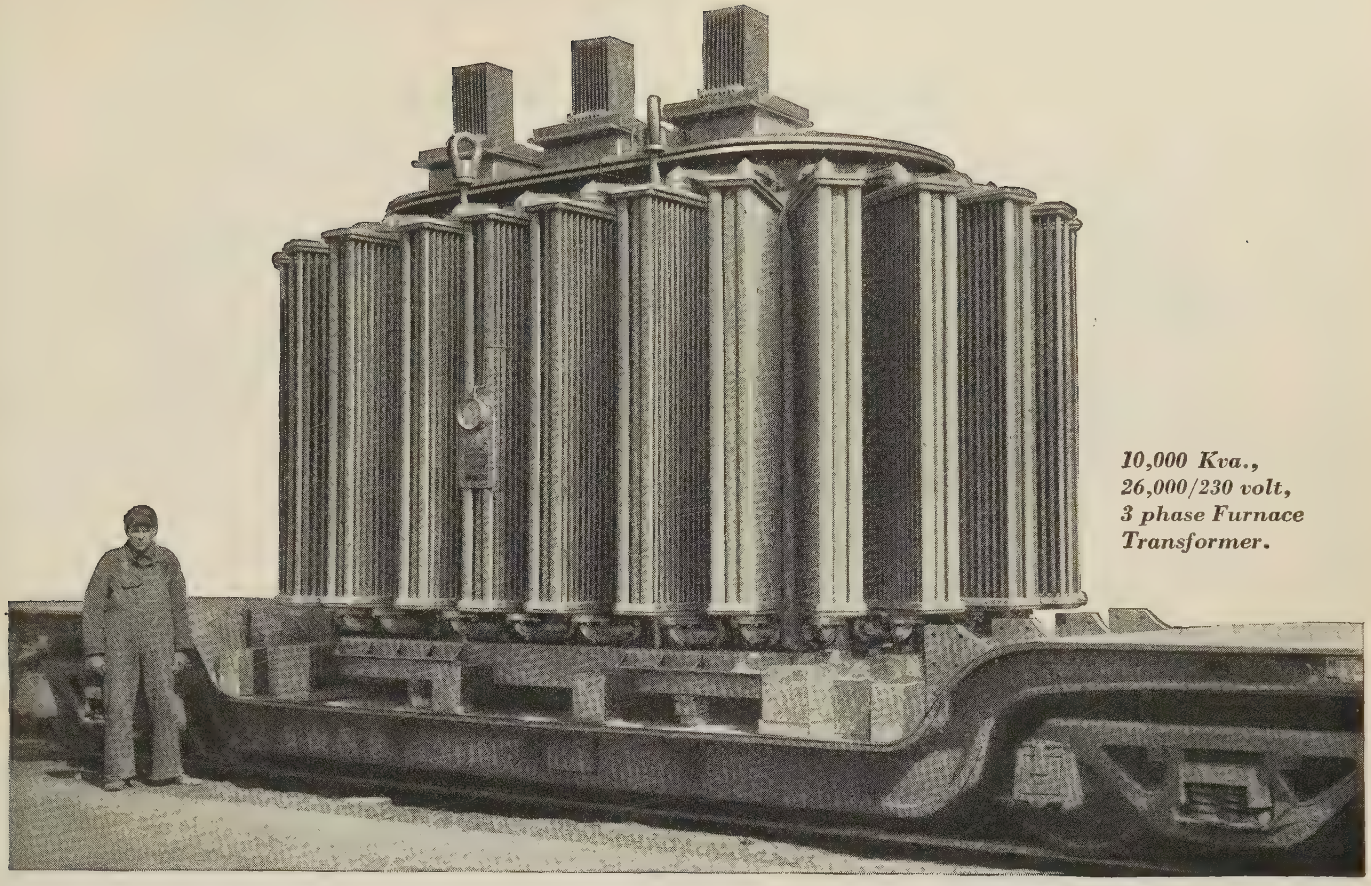

10,000 Kva., 26,000/230 volt, 3 phase Furnace Transformer.

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TRANSFORMERS such as the 10,000 Kva unit shown above ready for shipment have an unusually large current capacity. This unit has a primary voltage of 26,000 which is reduced to 230 volts to supply current for heating elements.

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- Flour and Saw Mill Machinery
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ALPHABETICAL LIST OF ADVERTISERS

PAGE

Allied Engineers, Inc. 32
Allis-Chalmers Manufacturing Company 39
Ambursen Construction Company, Inc. 32
American Bridge Company 37
American Lava Corporation 30
American Steel & Wire Company 2
American Telephone & Telegraph Co 41
American Transformer Company 26
Automatic Electric, Inc 35

Battey & Kipp, Inc 32
Black & Veatch 32
Bull Dog Electric Products Co. . . . . Fourth Cover
Burndy Engineering Company, Inc. 24
Burt, Dr. Robert C 32
Byllesby Engineering & Management Corp. . 32

Cambridge Instrument Company, Inc 28
Canadian Porcelain Company, Ltd 24
Chicago Transformer Company 16
Clement, Edward E 32
Condit Electrical Manufacturing Corporation . 18
Copperweld Steel Company 24
Corning Glass Works 8, 9

Delta-Star Electric Company 25
Dossert & Company 5

Electrad, Inc 17
Electric Controller & Mfg. Co., The 27
Electric Products Company, The 15
Electric Specialty Company 28
Electrical Testing Laboratories 38
Electro Dynamic Company 30
Engineering Directory 32

PAGE

Fennessy, David V 32
Ferranti, Incorporated 10
Fowle & Company, Frank F 32
Freyn Engineering Company 32

G & W Electric Specialty Company 7
General Radio Company 28

Hoosier Engineering Company 32

I-T-E Circuit Breaker Company 29

Jackson & Moreland 32

Kearney Corporation, James R 25
Kerite Insulated Wire & Cable Co., Inc 1
Kruse, Robert S 32

Lapp Insulator Company, Inc 13
Lee Engineering Corporation W. S 32
Locke Insulator Corporation 6

Malleable Iron Fittings Company 24
Manufacturers' & Inventors' Elec. Co 28
Memco Engineering & Mfg. Co., Inc 25
Metropolitan Device Corporation 42
Mica Insulator Company 23
Minerallac Electric Company 22
Moloney Electric Company 20
Morganite Brush Company, Inc 34

PAGE

Neall, N. J 32
Neiler, Rich & Company 32
Norma-Hoffmann Bearings Corporation 31

Ohio Brass Company 11
Okonite Company, The . . . . . Third Cover
Okonite-Callender Cable Co., Inc . . . Third Cover
Osgood, Farley 32

Railway & Industrial Engineering Company 25
Rockbestos Products Corporation 22
Roebling's Sons Company, John A 21
Roller-Smith Company 28
Rowan Controller Company, The 30

Sanderson & Porter 32
Sangamo Electric Company 19
Sargent & Lundy, Inc 32
Science Abstracts 40
Sharples Specialty Company 33
Simplex Wire & Cable Company 20
Sokol, S 32
Stevens, Inc., John A 32
Stockbridge & Borst 32

Texas Company, The 3
Thomas & Sons Company, The R 24

Wagner Electric Corporation 4
Ward Leonard Electric Company 26
Western Electric Company 12
Weston Electrical Instrument Corporation . . . 14
West Va. Pulp & Paper Company 30
White Engineering Corp., The J. G 32
Wray & Company, J. G 32

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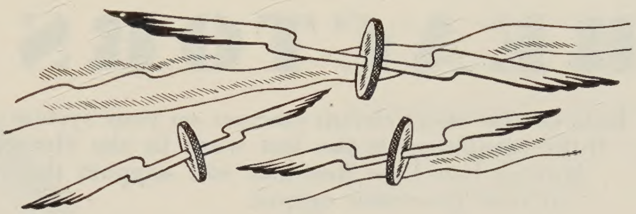

DAY in and day out you take wings by talking over your telephone . . . with friends . . . the grocer . . . the doctor . . . a relative hundreds of miles away . . . and every month you get a bill for this service.

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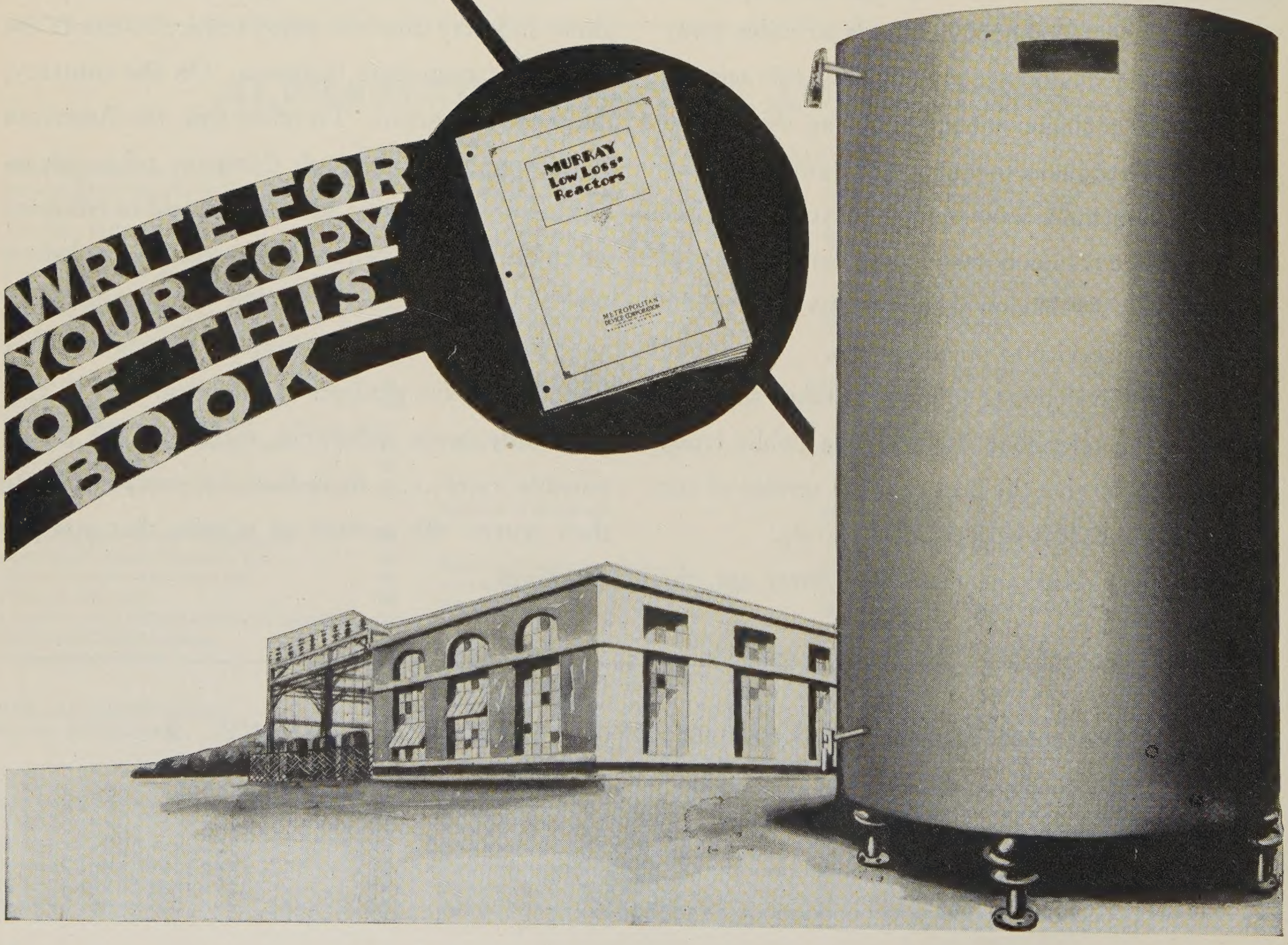
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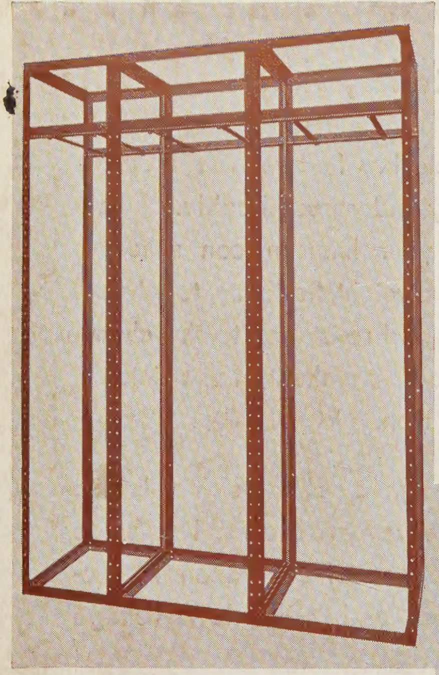

Stock angle iron Switchboard Frames, drilled and tapped for the mounting of Switches, etc. Note, at top, integral Pull Box section with cable racks. Sides and rear of Frames are closed with plates of furniture steel or doors and trims.

Bull Dog's latest development introduces to Switchboard construction the many advantages which the SAFtoFUSE brought to the Panelboard field.

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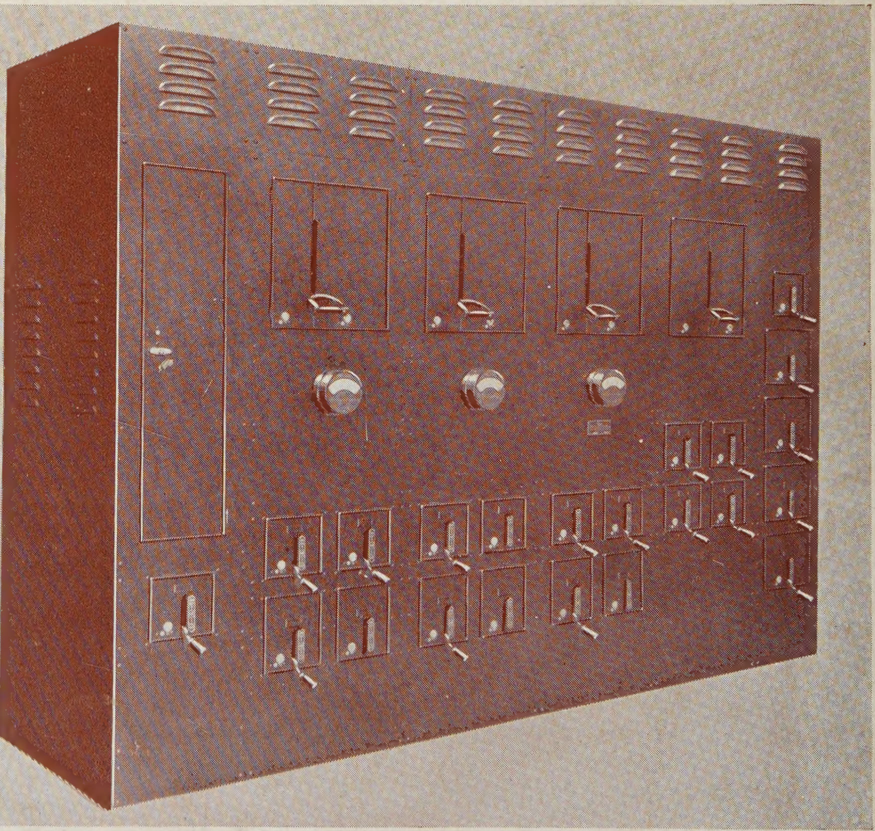
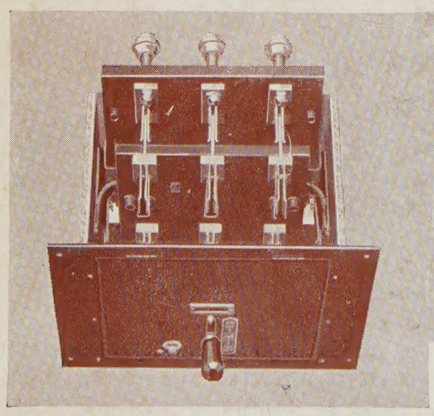


Model DF30 SAFtoSWITCH-BOARD. Note—complete standardization of Meters, Externally Operated Dead Front Circuit Breakers, DF30 Switches and SAFtoFUSE Distributing Panels—space under Meters for installing additional Switches any time. Removable sides and rear doors give access to Busbars, Switches and Wiring. Pull Box at top integral unit.



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